PREPARED BY
CHEMICAL ENGINEERING DIVISION
INDUSTRIAL TECHNOLOGY CENTRE/
MANITOBA RESEARCH COUNCIL

METHANOL FLEET TEST

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MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources — oil and natural gas — are becoming less accessible and more costly. However, Canada is well-endowed with renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminated March 31, 1984. The Agreement was dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program had a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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EXECUTIVE SUMMARY

This report summarizes the interim results from the second phase of the methanol fleet test, covering the period August, 1984 to January, 1985. The contract extends to March, 1985. This phase was funded under the Manitoba/Canada Conservation and Renewable Energy Demonstration Agreement (CREDA). The objective of the project was to test and demonstrate the use of methanol as a vehicle fuel by comparing the overall performance of a fleet operating on regular unleaded gasoline with that of a fleet operating on a low methanol (test) blend.

The test blend consisted of 4.75% methanol, 4.75% isobutanol and 90.5% regular unleaded gasoline. The fuel was bulk blended and conformed to the Canadian General Standards Board draft specifications for "unleaded oxygenated automotive gasoline".

The test blend fleet and regular unleaded gasoline fleet consisted of 44 and 31 vehicles, respectively. Vehicles used in the demonstration were supplied by the Manitoba Telephone System, the Canadian Motor Vehicles Manufacturer's Association and Toyota Technical Centre, Inc. U.S.A.

During the first five months of the demonstration, the regular unleaded gasoline fleet travelled approximately 127,000 km and the test blend fleet approximately 175,000 km.

The performance of the fuels was compared by 4 tests.

- A weekly driver survey provided information on general driveability and operating problems.
- Controlled driveability testing allowed for an unbiased evaluation of vehicle driveability.
- Fleet fuel consumption data provided a field comparison of fuel energy economy.
- Chassis dynamometer testing yielded a controlled condition comparision of fuel energy economy.

Specific test results are as follows:

- Fleet Driveability: Higher demerits were reported initially for the test blend fleet compared to the regular unleaded gasoline fleet. The major problems reported were hesitation, stumbling, stalling after starting and lack of power. These problems were due to the blend having a lower vapour pressure than was normal for gasoline at the specific time of year. With the addition of butane to the blended fuel during the winter months, demerits decreased for the blend test fleet.

EXECUTIVE SUMMARY - Continued

- Controlled Driveability: A driveability test route was developed at ITC to evaluate vehicle driveability on test fuels. Results of nine tests, conducted to date, show that there is no significant difference in driveability demerits at the 90% confidence level.

- Fleet Energy Consumption: Of the matched vehicle types used in the demonstration, the test blend fleet used 11.2% more energy per unit distance than the regular unleaded gasoline fleet.

- Chassis Dynamometer: Chassis dynamometer testing yielded 1.9% and 0.6% greater specific energy consumption, on average, for vehicles running on test blend fuel at 48 km/h and high load and 88 km/h and low load than on regular unleaded gasoline. These differences were not statistically significant at a confidence level of 90%. These tests permitted a valid comparison of fuels by elminiating many of the uncontrolled conditions found in fleet operation.

  Experience to date shows that the CGSB fuel can be formulated to give similar driveability to seasonally adjusted gasoline. As only one winter of operation has been completed, further testing is required.

SOMMAIRE

Le présent rapport résume les résultats provisoires obtenus à l'issue de la deuxième phase des essais d'alimentation au méthanol d'un parc de véhicules automobiles, essais qui se sont déroulés entre août 1984 et janvier 1985. Le contrat se poursuit jusqu'à mars 1985. Les subventions de la présente phase proviennent du Programme (Canada-Manitoba) de démonstration des énergies renouvelables et des économies d'énergie (PDÉRÉÉ). Le projet avait pour objet de mettre à l'essai des véhicules roulant au méthanol et de démontrer l'usage du méthanol comme carburant automobile, en comparant le rendement global d'un parc de véhicules roulant à l'essence ordinaire sans plomb à un parc de véhicules roulant à un mélange à faible teneur en méthanol.

Le mélange d'essai était composé de 4,75 % de méthanol, de 4,75 % d'isobutanol et 90,5 % d'essence ordinaire sans plomb. Le carburant a été mélangé en vrac conformément aux dispositions du projet de norme pour essence automobile oxygénée sans plomb, publié par l'Office des normes générales du Canada (ONGC).

Le parc d'essai roulant au mélange d'essai et celui roulant à l'essence sans plomb comportaient respectivement 44 et 31 véhicules fournis par le Système de téléphone du Manitoba, la Société des fabricants des véhicules à moteur et le Toyota Technical Centre Inc., aux États-Unis.

Pendant les cinq premiers mois d'essai, les véhicules roulant à l'essence ordinaire sans plomb ont couvert près de 127 000 km, contre près de

175 000 km pour les véhicules roulant au mélange d'essai.

Les deux types de carburants ont fait l'objet des quatre essais de rendement suivants:

- Sondage hebdomadaire auprès des conducteurs pour recueillir des données sur l'agrément de conduite (conduisabilité) et les difficultés de fonctionnement.

- Évaluation de l'agrément de conduite sous conditions contrôlées pour évaluer de façon objective l'agrément de conduite des véhicules.

- Consommation en carburant des parcs pour recueillir des données sur les économies éventuelles d'énergie.

- Essais sur dynamomètre pour établir les courbes comparatives de consommation sous conditions contrôlées.

Les résultats de ces essais se présentent comme suit:

- Agrément de conduite: Le parc de véhicules roulant au mélange d'essai a d'abord recueilli des résultats moins favorables que ceux du parc roulant à l'essence ordinaire sans plomb. Parmi les principales anomalies signalées: ratés, hésitations en marche, calage au démarrage et perte de puissance. Ces difficultés provenaient de la faible tension de vapeur du mélange d'essai par rapport à l'essence ordinaire sans plomb pour cette période particulière de l'année. L'addition de butane

au carburant d'essai pendant l'hiver a permis de réduire l'intensité des anomalies constatées.

- Agrément de conduite sous conditions contrôlées: Un circuit routier a été tracé à ITC pour évaluer l'agrément de conduite des véhicules roulant au carburant d'essai. Les résultats des neuf essais effectués jusqu'à ce jour permettent de démontrer qu'il n'existe pas de différence notable dans les anomalies de conduite dans l'intervalle de confiance de 90 %.

- Consommation d'énergie du parc: On a constaté, parmi les véhicules comparables issus des deux parcs, que les véhicules roulant au mélange d'essai consommaient 11,2 % plus d'énergie par unité de distance que les véhicules roulant à l'essence ordinaire sans plomb.

- Essais au dynamomètre: Les essais au dynamomètre ont donné les résultats suivants: consommation spécifique moyenne d'énergie supérieure respectivement de 1,9 % et 0,6 % pour les véhicules roulant au mélange d'essai à 48 km/h sous forte charge et à 88 km/h sous faible charge, par rapport aux véhicules roulant à l'essence ordinaire sans plomb. Ces différences ne constituent pas un écart notable sur le plan statistique à un intervalle de confiance de 90 %. Ces essais ont permis d'effectuer une comparaison valable des carburants utilisés, par élimination des nombreuses variables qui se présentent en usage normal sur route.

L'expérience ainsi acquise démontre qu'il est possible de modifier la formulation du carburant ONGC pour obtenir le même agrément de conduite qu'avec l'essence adaptée aux conditions climatiques. Étant donné que les essais n'ont porté que sur un seul hiver, il est nécessaire de poursuivre l'expérience.

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1. INTRODUCTION

A methanol transportation fuel demonstration is presently in progress in the Province of Manitoba. Phase II of this demonstration was jointly funded by Energy, Mines and Resources, Canada, and Energy and Mines, Manitoba, under CREDA.

The objective of this project was to test and demonstrate the use of methanol as a vehicle fuel under Manitoba climatic conditions. The fuel tested was a low percentage methanol blend, designated as test blend, consisting of 4.75% methanol, 4.75% isobutanol and 90.5% tailored regular unleaded gasoline.

This fuel was bulk blended and conformed to the Canadian General Standards Board (CGSB) draft specifications for unleaded oxygenated automotive gasoline for Manitoba region.

The project combined engineering tests and field trials under the management of the Industrial Technology Centre (ITC).

The field trials were conducted using two fleets of vehicles, 44 vehicles operating on test blend and 31 operating on regular unleaded gasoline.

The Manitoba Telephone System (MTS) particpated in the program by supplying a total of 50 vehicles. The Motor Vehicle Manufacturer's Association (MVMA) and Toyota supplied an additional 25 vehicles.

Canadian Methanol Canadien (CMC) provided two dispensing facilitites for the bulk blended test fuel in convenient areas in the City of Winnipeg. Results presented in this report are for the period August 1984 to January 1985.

2. SCOPE OF FLEET TEST

2.1 Test Fleet Description

Two fleets of spark ignition vehicles were used for the demonstration test and are listed in Table I. A more detailed vehicle identification description list is presented in Table II.

Table I: Phase II Test Vehicles

Vehicle Source	Test Blend Fleet	RUG Fleet
MTS Fleet	25	25
MVMA Fleet		
- General Motors	6	3
- Chrysler	3	3
- Ford	6	-
- American Motors	2	-
Toyota	2	-
TOTAL	44	31

Table II: Phase II Vehicle Identification List

Vehicle Type	Year	Make	Number of Vehicles		Engine Size (L)	Transmission	Number of Cylinders	Fuel Delivery System*
			Test Blend	RUG				
A	1981	Ford Escort	2	2	1.6	4 Standard	4	C
B	1982	Ford Escort	4	4	1.6	4 Standard	4	C
C	1983	Toyota Corolla	1	-	1.6	3 Automatic	4	C
D	1985	Ford Escort	1	-	1.6	4 Standard	4	EFI
E	1985	Renault Alliance	1	-	1.7	3 Automatic	4	TBI
F	1981	Ford Ranger	1	1	2.0	4 Standard	4	C
G	1983	Ford Courier	1	1	2.0	4 Standard	4	C
H	1984	Dodge Mini-Van	2	2	2.2	4 Standard	4	C
I	1985	Dodge K-Wagon	1	1	2.2	3 Automatic	4	C
J	1980	Ford Fairmont	3	3	2.3	4 Standard	4	C
K	1980	Ford Zephyr	1	1	2.3	4 Standard	4	C
L	1985	Ford Thunderbird	1	-	2.3	5 Standard	4	EFI
M	1985	Ford LTD	1	-	2.3	3 Automatic	4	C
N	1985	Ford Tempo	1	-	2.3	3 Automatic	4	C
O	1984	Pontiac 6000	2	1	2.5	3 Automatic	4	TBI
P	1983	Toyota Cressida	1	-	2.8	3 Automatic	6	EFI
Q	1984	Chev Celebrity	2	1	2.8	3 Automatic	6	C
R	1980	Dodge Pick-up	1	1	3.7	4 Standard	6	C
S	1985	Dodge Pick-up	1	1	3.7	3 Automatic	6	C
T	1979	AMC Concord	1	1	3.8	4 Standard	6	C
U	1985	Buick Century	2	1	3.8	4 Automatic	6	EFI
V	1985	Mercury Marquis	1	-	3.8	3 Automatic	6	C
W	1980	GMC Van	2	2	4.1	3 Standard	6	C
X	1985	AMC Eagle	1	-	4.2	3 Automatic	6	C
Y	1979	Ford Van	1	1	4.9	3 Standard	6	C
Z	1980	Ford Van	1	1	4.9	3 Standard	6	C
AA	1982	Ford Van	1	1	4.9	3 Standard	6	C
BB	1985	Lincoln Towne Car	1	-	5.0	3 Automatic	8	C
CC	1985	Dodge Van	1	1	5.2	3 Automatic	8	C
DD	1980	Chev Van	1	1	5.7	3 Automatic	8	C
EE	1982	GMC Van	1	1	5.7	3 Standard	8	C
FF	1982	Ford Van	2	2	5.8	3 Automatic	8	C

* C - Carbureted
EFI - Electronic Fuel Injection
TBI - Throttle Body Injection

The General Motors and Chrysler vehicles were operated by MTS. Ford vehicles were operated by Ford representatives in the Winnipeg area and the American Motors and Toyota vehicles were operated by ITC personnel. The total test fleet was comprised of 44 vehicles operated on the test blend and 31 vehicles operated on regular unleaded gasoline.

All but one of the vehicles used in the Phase I M5 fleet test had carbureted fuel delivery systems. In the second phase, the following vehicles had fuel injection delivery systems:

Throttle Body Injection (TBI) - E, O
Electronic Fuel Injection (EFT) - D, L, U, P

No modifications were made to the test blend vehicles prior to the start of the demonstration.

2.2 Development of Fuels

In Phase I, the test fuel was pump blended. Because of the extreme variation in alcohol levels experienced with pump blending, the Phase II fuel was bulk blended. This fuel was available at two service stations located in the City of Winnipeg.

The test blend fuel evaluated consisted of a blend of 4.75% methanol, 4.75% isobutanol and 90.5% regular unleaded (tailored) gasoline and was blended to conform to the draft specifications of the CGSB for unleaded oxygenated automotive gasoline (see Appendix I).

The fuel was developed and supplied in coordination with CMC and the Co-op Refinery in Regina, Saskatchewan. The Co-op Refinery provided a tailored gasoline that, when mixed with the alcohols was within CGSB specifications for this region.

The regular unleaded gasoline (RUG) used in the demonstration was blended to conform to the draft specifications of the CGSB for unleaded automotive gasoline for this region. This fuel was dispensed by an MTS tanker truck.

2.2.1 Fuel Quality Control

To ensure conformity to fuel specificaitons, each batch of the test blend fuel was tested at the ITC chemical laboratory as follows:

- percent methanol
- percent isobutanol
- percent moisture
- ASTM distillation
- vapour pressure
- heat of combustion
- percent aromatics
- chlorides

The regular unleaded gasoline was tested monthly for the following:

- percent moisture
- ASTM distillation
- vapour pressure
- heat of combustion
- percent aromatics

Starting in January 1985, weekly testing for vapour pressure and ASTM distillation on the test blend and RUG was initiated.

2.3 Materials to Fuel Compatibility

The fuel used to test compatibility was the tailored gasoline blended with 4.75% methanol and 4.75% isobutanol, as supplied by CMC. This fuel has corrosion inhibitors, Dupont DMA-54 and Ethyl 733, added to it. The water content of the blend was adjusted to 0.05%, as a "wet" fuel would be expected to have a greater corrosive effect. The fuel was also characterized as to specific gravity and distillation curve.

Metals used were those typically found in automotive fuel systems, and include aluminum alloys, brass, steels, zinc alloys, terne plate, magnesium alloys and copper. The surfaces of test metal coupons were wet ground using 600 grit metallurgical grade silicon carbide. Each test coupon was then weighed and measured, prior to immersion.

Two coupons of each metal were immersed in about 400 mL of fuel, in such a fashion that the coupons were suspended away from the container walls and each other. The only other materials in contact with the fuels were glass and Teflon. Test jars contain only one type of metal. The containers were sealed and stored at ambient laboratory temperatures in a closed, vented storage cabinet. The jars are monitored monthly for weight loss, and if necessary, additional fuel is added and the container resealed.

The expected duration of the test will be one year, at which time the coupons will be examined for changes in surface appearance and weight gain or loss.

2.4 Engine Dynamometer Testing

A 4 cylinder, 1.6 L, Ford Escort engine was purchased to evaluate both the test blend and gasoline fuels. A complete engine performance map, in accordance with SAE test code J1312 will be completed on the two fuels.

Aldehyde emissions analysis will also be performed.

2.5 Chassis Dynamometer Testing

Chassis dynamometer tests were performed on a Sun Road-A-Matic chassis dynamometer at the Manitoba Telephone System test facility. These compared the performance of the same vehicles on both the test fuel and RUG. Two speeds (48 and 88 km/h) were used in the comparison. These speeds were chosen to simulate city and highway driving conditions (at steady state conditions) and are also those recommended in the Sun specification manual.

The specific fuel and energy consumptions were determined for each test. Emissions, from selected vehicles, were analyzed for aldehyde content.

2.6 Driving Cycle Tests

A fuel economy measurement test and a controlled driveability test are planned in the demonstration.

2.6.1 Fuel Economy Measurement

The first test consists of measuring the fuel economy of selected vehicles, in accordance with Fuel Economy Measurement - Road Test Procedure - SAE J1082. A flow meter, fuel totalizer and fifth wheel system were purchased to conduct the tests. Both fuels will be tested.

2.6.2 Driveability Comparison

This second test consisted of driving the vehicles around a pre-determined course to evaluate vehicle driveability on both the test blend fuel and RUG. This test was limited to a selected number of cars.

A demerit point system was developed at ITC (based on the demerit system at CRC) to determine the overall driveability rating of the vehicle. A vacuum gauge was used to ensure that consistent procedures be used for each test. A detailed report of the driveability test and demerit system is given in Appendix II.

2.7 Fleet Driveability

A separate driveability test was developed at ITC different from that described above, which included all vehicles and which is based on the weekly log. A demerit scoring system was designed to allow comparison of test blend fueled vehicles with RUG fueled vehicles by assigning demerit points to vehicle operator responses on the "Fleet Testing Survey - Weekly Log Sheet" (Figure 1).

The first 10 engine/fuel related questions were assigned a weighting factor. The rating factors reflect the relative severity or unacceptability of the engine faults. The more undesirable faults (with respect to vehicle driveabilty and safety) were assigned higher weighting factors.

INDUSTRIAL TECHNOLOGY CENTRE/MANITOBA RESEARCH COUNCIL

Fleet Testing Survey - Weekly Log Sheet

Vehicle No.: _____ Type: _____

Date: _____ Driver Name: _____

Odometer Reading: _____ Fuel Used: _____

Servicing: Litres of Oil Added: _____

Maintenance Required: Yes_____ No____

If yes, please describe: _____

_____

_____

Please rate the following engine related characteristics (mark appropriate column with a check)

		Good=0	Acceptable=2	Poor=4
1) Cranking time to start engine	=1	0	2	4
2) Engine idling	=1	0	2	4
3) Overall performance	=2	0	4	8
4) Power	=1	0	2	4
		Never	**Occasionally**	**Often**
5) Stalling after starting	=4	0	8	16
6) Stalling in traffic	=16	0	32	64
7) Engine knock or pinging	=1	0	2	4
8) Engine run-on or dieseling	=2	0	4	8
9) Hesitating, stumbling or bucking	=6	0	12	24
10) Backfiring	=4	0	8	16

If any problems occur, please describe the type of driving and the approximate temperature for each problem:

0 « TWD « 152

_____

_____

_____

_____

Figure 1: Fleet Testing Survey - Weekly Log Sheet

These questionnaires were placed in all the test vehicles. They were completed and submitted on a weekly basis to ITC for data analysis. Further information is given in Appendix II, Section 5.

2.8 Oil Analysis and Maintenance

The oil change and maintenance programs for test blend and RUG fueled vehicles were performed on the same basis as the Manitoba Telephone System standard schedule.

The oil was monitored on five representative test blend vehicles, five RUG fueled vehicles and all the MVMA and Toyota vehicles. PetroCan supplied a 5W30 weight motor oil for the above vehicles.

To determine whether the test fuel was causing unacceptable lubricant deterioration and/or accelerated engine wear, the crankcase oil was analyzed for wear metals, total base number, pentane insolubles and toluene solubles. The oil was also tested for fuel dilution and kinematic viscosity. A typical oil analysis sheet is shown in Figure 2.

2.9 Failure Analysis

During the term of the demonstration all engine breakdowns were recorded. Those problems that could be attributed to the fuel were to be subjected to a detailed investigation.

2.10 Safety Study

In conjunction with the demonstration program, a survey is being made of existing literature, covering toxicology of methanol fuels and possible hazards associated with them. A report will be issued at the conclusion of the second phase of the project.

3. RESULTS AND DISCUSSION

3.1 Fuel Quality

The base gasoline used for preparation of the test blend for use from August to November, was received August 24, 1984. The test fuel was bulk-blended at a blending facility in Winnipeg, and delivered to the Ness station on August 27, 1984 and to the Pembina station on September 19, 1984.

The test blend fuel was within CGSB specifications for this region for August, September and October, 1984. The RON and MON were 94.5 and 81.5, respectively. Fuel quality is presented in Tables III and IV.

Crankcase Oil Analysis

Vehicle Description: _____ _____ Km on vehicle: _____

_____ _____ _____ Km on Oil: _____

CMC Number : _____ _____ Date sampled: _____

MTS Number: _____

ITC Sample Number: _____ _____ Project Number: _____

Pentane Insolubles Toluene Solubies Total Base No. Fe Cr Pb Cu Ni Sn Al

K. Vis. @ 37.8°C _____ Fuel Dilution: MeOH/IBA _____

@ 98.9°C _____ Gasoline _____

Comments: _____

_____

Analyst: _____ Date Reported: _____

NOTE: Metal content given in parts per million

Total Base Number is defined as the quantity of acid, expressed as milligrams of potassium hydroxide, that is required to neutralize all basic constituents present in 1 gram of sample.

Pentane insolubles contain all non-oil contaminants.

Toluene solubles represent the oxidative material present.

Figure 2: Crankcase Oil Analysis Sheet

Table III: Test Blend Fuel Analyses

Date	Fuel Station	Vapour Pressure (kPa)	Methanol (vol/vol %)	Isobutanol (vol/vol %)	Aromatics (vol/vol %)	Water (wt/vol %)	Energy (MJ/L)	Chlorides (ug/g)
Aug 27/84	N	64	4.82	4.65	33.01	0.01	33.56	--
Sep 19/84	P	63	4.82	4.66	33.01	0.01	33.56	4.5
Dec 13/84	P	59	--	--	--	--	--	--
Dec 19/84	P	87	4.90	4.66	--	0.06	--	6.6
Dec 19/84	N	80	4.55	4.50	--	0.08	--	6.6
Jan 2/85	P	93	--	--	--	--	--	--
Jan 11/85	P	91	--	--	--	--	--	--
Jan 17/85	P	91	--	--	--	--	--	--
Jan 24/85	P	90	--	--	--	--	--	--
Jan 29/85	P	90	5.16	4.93	29.04	0.04	33.40	--
Jan 29/85	N	87	4.96	4.83	29.76	0.02	33.58	--
Feb 8/85	P	88	--	--	--	--	--	--
Feb 14/85	P	85	--	--	--	--	--	--
Feb 18/85	P	101	--	--	--	--	--	--

P - Pembina Station

N - Ness Station

Table IV: Distillation Data for the Test Blend Fuel

ASTM Distillation	Aug 27/84	Dec 13/84	Dec 19/84	Dec 19/84	Jan 2/85	Jan 11/85	Jan 17/85
IBP	34.5	33.0	28.5	29.0	33.0	28.0	26.5
5% Recovered	46.0	45.0	41.5	41.0	42.5	40.5	38.0
10% Recovered	50.5	49.0	48.0	47.0	47.5	46.0	45.0
20% Recovered	62.5	60.0	59.0	59.0	59.0	57.5	55.5
30% Recovered	85.0	83.0	83.0	82.5	81.5	80.5	80.0
40% Recovered	98.0	96.0	97.0	97.0	96.5	97.0	96.0
50% Recovered	111.0	108.5	111.5	110.0	110.0	109.5	110.5
60% Recovered	124.5	123.5	126.0	125.0	115.0	125.5	125.5
70% Recovered	137.5	135.5	142.0	139.0	139.5	139.5	140.0
80% Recovered	152.0	149.5	156.0	155.0	156.5	154.5	154.0
90% Recovered	169.0	167.5	181.0	176.0	179.0	177.0	177.0
95% Recovered	183.5	181.5	--	199.0	--	--	--
FBP	202.5	203.5	204.5	203.5	206.0	204.5	202.0
Recovery	99.0	99.5	95.0	96.5	95.5	95.5	95.5

Continued ...

Table IV: Distillation Data for the Test Blend Fuel - continued

ASTM Distillation	DATE					
	Jan 24/85	Jan 29/85	Jan 29/85	Feb 8/85	Feb 14/85	Feb 19/85
IBP	32.0	32.5	29.5	27.5	28.5	29.0
5% Recovered	43.0	42.0	42.5	39.5	42.5	39.5
10% Recovered	48.5	475.	48.0	45.5	48.5	45.0
20% Recovered	59.5	58.5	60.5	57.0	60.5	57.0
30% Recovered	79.5	80.0	83.5	78.0	83.5	79.0
40% Recovered	96.0	97.0	99.0	96.0	99.0	97.0
50% Recovered	110.0	110.0	112.0	108.5	111.5	110.5
60% Recovered	125.0	125.0	127.0	123.0	126.0	125.5
70% Recovered	139.5	138.0	141.0	138.0	140.0	141.0
80% Recovered	153.5	154.5	157.0	152.0	154.0	157.0
90% Recovered	176.0	175.0	176.5	172.5	176.0	180.0
95% Recovered	201.0	198.5	--	192.0	199.5	--
FBP	207.0	207.0	205.0	202.0	206.5	211.0
Recovery	96.5	97.0	96.5	97.5	97.0	95.5

It was assumed that all the MVMA vehicles would be available in September. As this was not the case, the fuel (which had a vapour pressure below "spec" for the winter) was still in use in November.

A second batch of base gasoline used for preparation of the test blend for the December to March period was received November 20, 1984. The resultant test blend vapour pressure was 77 kPa. The technical committee (see minutes of the December 12 meeting) felt that this was too low and should be increased to match that of the RUG used at MTS which had a vapour pressure of 91 kPa. Subsequently, 6.0% butane was added to obtain a VP of 91 kPa. This modified test blend fuel was delivered to the service stations for dispensing to vehicles on December 18, 1984. The RON and MON were 94.0 and 82.2, respectively.

The RUG fuel was sampled on a monthly basis for VP, aromatics, water, energy and distillation curve. Weekly samples were taken for VP and distillation analysis. These results are presented in Tables V and VI.

As can be seen in the table, the vapour pressure of the RUG was within CGSB specifications since the start of the demonstration. Over the same period of time there was a large change in the aromatics content of the RUG. In August, the aromatics content was 8.03% and increased to 34.54% on January 29, 1985. Further, the T50 and T90 (the temperature at which 50% and 90% of the fuel is recovered according to the ASTM D86 distillation procedure) was above CGSB specifications on January 11, 17 and 24. This problem was identified as originating with Shell RUG and gasoline fractions produced by hydro treatment of synthetic crude oil.

Subsequently, a survey of 10 service stations was conducted on February 1 and 5. Those stations serviced by Shell, (i.e. Domo, PetroCan and Gulf), had their RUG replaced by Super unleaded fuel on February 1. It was noted that the fuel dispensed at two stations fell below the winter grade VP as specified by CGSB and at two other stations the VP's were border line. (Table VII).

ASTM distillation curves for the test blend and RUG fuels are given in Figures 3 to 5.

Table V: Regular Unleaded Gasoline Fuel Analyses

Date	Vapour Pressure (kPa)	Aromatics (vol/vol %)	Water (wt/vol %)	Energy (MJ/L)
Aug 30/84	54	8.03	<0.01	33.62
Oct 2/84	80	10.54	<0.01	33.49
Oct 30/84	87	10.31	<0.01	33.44
Dec 4/84	93	20.66	<0.01	33.76
Dec 19/84	79	--	--	--
Jan 2/85	101	--	--	--
Jan 11/85	98	--	--	--
Jan 17/85	91	--	--	--
Jan 24/85	85	34.54	--	--
Jan 29/85	90	34.20	<0.01	34.30
Feb 8/85	86	--	--	--
Feb 14/85	103	--	--	--
Feb 22/85	95	--	--	--

Table VI: Distillation Data for Regular Unleaded Gasoline

ASTM D86 Distillation	DATE							
	Aug 30/84	Oct 2/84	Oct 30/84	Dec 4/84	Dec 19/84	Jan 2/85	Jan 11/85	Jan 17/85
IBP	28.0	29.0	26.0	26.0	28.0	25.5	24.0	30.5
5% Recovered	45.0	41.0	38.0	38.0	37.0	33.5	32.5	38.5
10% Recovered	48.5	47.0	43.5	44.5	42.5	38.5	39.0	44.0
20% Recovered	72.0	60.0	56.5	58.0	55.0	51.5	54.0	57.0
30% Recovered	87.0	73.0	71.5	74.0	71.0	67.5	75.0	74.0
40% Recovered	96.0	86.0	85.5	89.0	86.0	83.0	91.0	98.0
50% Recovered	102.5	96.0	96.5	97.5	99.0	96.0	121.0	122.5
60% Recovered	108.5	103.5	107.0	114.0	111.0	108.5	143.0	144.0
70% Recovered	117.0	112.0	117.0	129.0	125.0	120.5	158.0	158.5
80% Recovered	135.5	125.5	136.5	150.5	148.0	143.0	171.5	171.0
90% Recovered	178.0	154.0	171.0	181.5	178.0	174.5	196.5	192.0
95% Recovered	200.0	178.5	202.0	--	--	205.5	--	--
FBP	213.0	198.5	206.0	210.0	208.0	206.0	221.5	222.0
Recovery	97.5	99.0	96.5	94.5	96.0	96.0	94.0	95.0

Continued ...

Table VI: Distillation Data for Regular Unleaded Gasoline - continued

ASTM D86 Distillation	DATE				
	Jan 24/85	Jan 29/85	Feb 8/85	Feb 14/85	Feb 22/85
IBP	24.0	24.5	26.0	24.5	26.5
5% Recovered	34.0	34.0	35.0	33.5	36.0
10% Recovered	40.0	40.5	40.5	40.0	42.0
20% Recovered	53.0	52.5	53.0	52.5	54.5
30% Recovered	69.5	67.0	69.0	68.0	70.0
40% Recovered	89.5	85.0	87.0	86.5	87.0
50% Recovered	113.5	106.5	107.0	108.5	99.5
60% Recovered	139.0	131.5	129.0	133.5	123.0
70% Recovered	155.5	152.5	150.0	154.5	144.0
80% Recovered	169.0	167.0	166.0	169.0	160.0
90% Recovered	186.0	184.5	183.5	186.0	184.0
95% Recovered	214.0	218.0	214.0	--	216.0
FBP	221.0	222.0	229.5	221.0	220.0
Recovery	96.5	96.0	97.0	96.0	96.0

Table VII: Vapour Pressures of Regular Unleaded Gasoline in the City of Winnipeg

Date	Location	RVP
Feb 1/85	Esso - RUG (Hwy #1)	94
Feb 1/85	Shell - RUG (Fermor	98
Feb 1/85	Shell - RUG (Archibald)	68*
Feb 1/85	PetroCan - RUG (Lag & Hwy #1)	67*
Feb 5/85	PetroCan - RUG (Marion)	72
Feb 5/85	Tempo - RUG (Dawson Rd)	96
Feb 5/85	Esso - RUG (St. Annes)	71
Feb 5/85	Gulf - RUG (Dawson)	89
Feb 5/85	Texaco - RUG (St. Annes)	89
Feb 5/85	Shell - RUG (Fermor)	90

* According to CGSB specifications the minimum gasoline vapour pressure allowed for this region is 69 kPa for the months from November to March

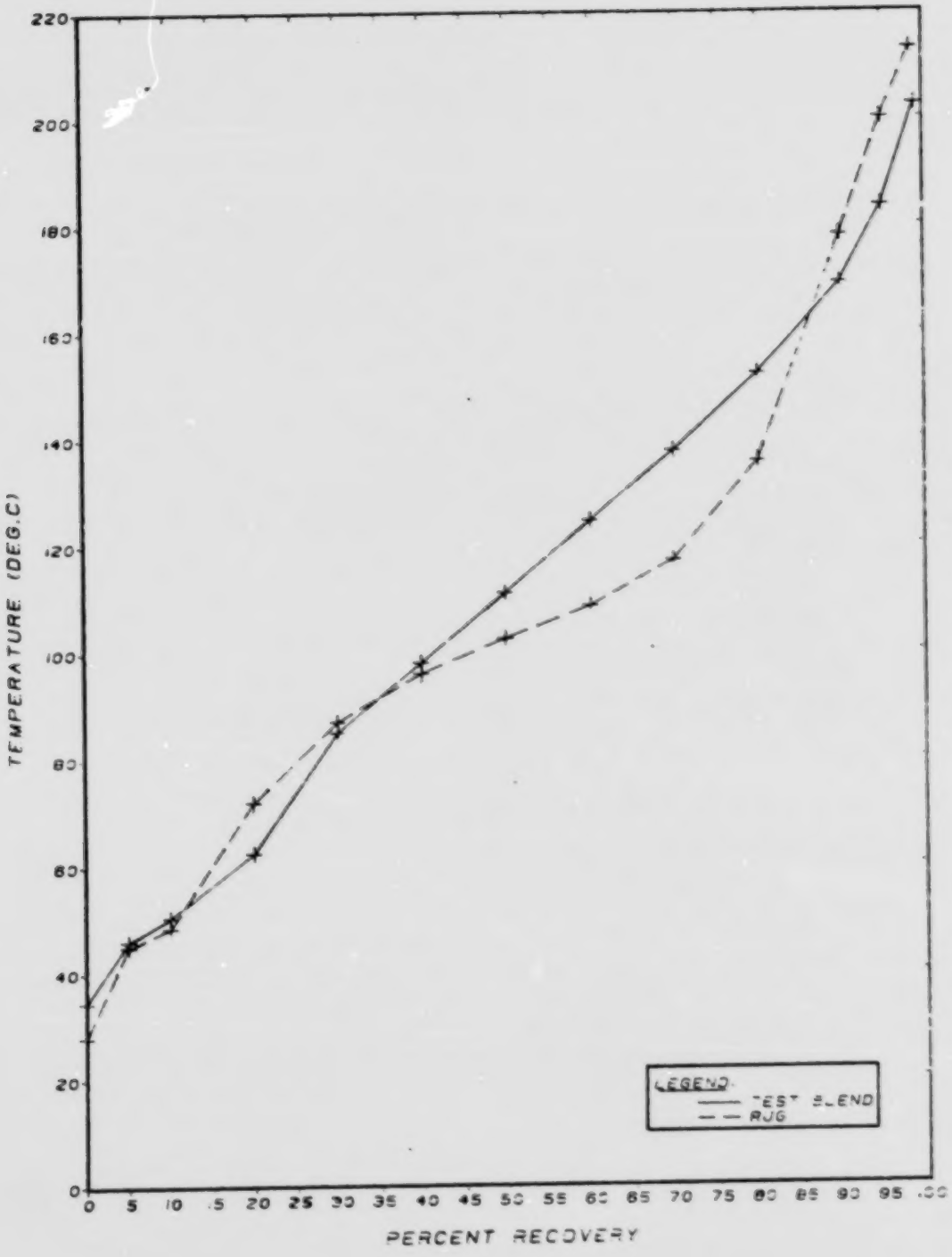


Figure 3: ASTM Distillation Curves
August 27 (Test Blend)
and August 30 (Rug)

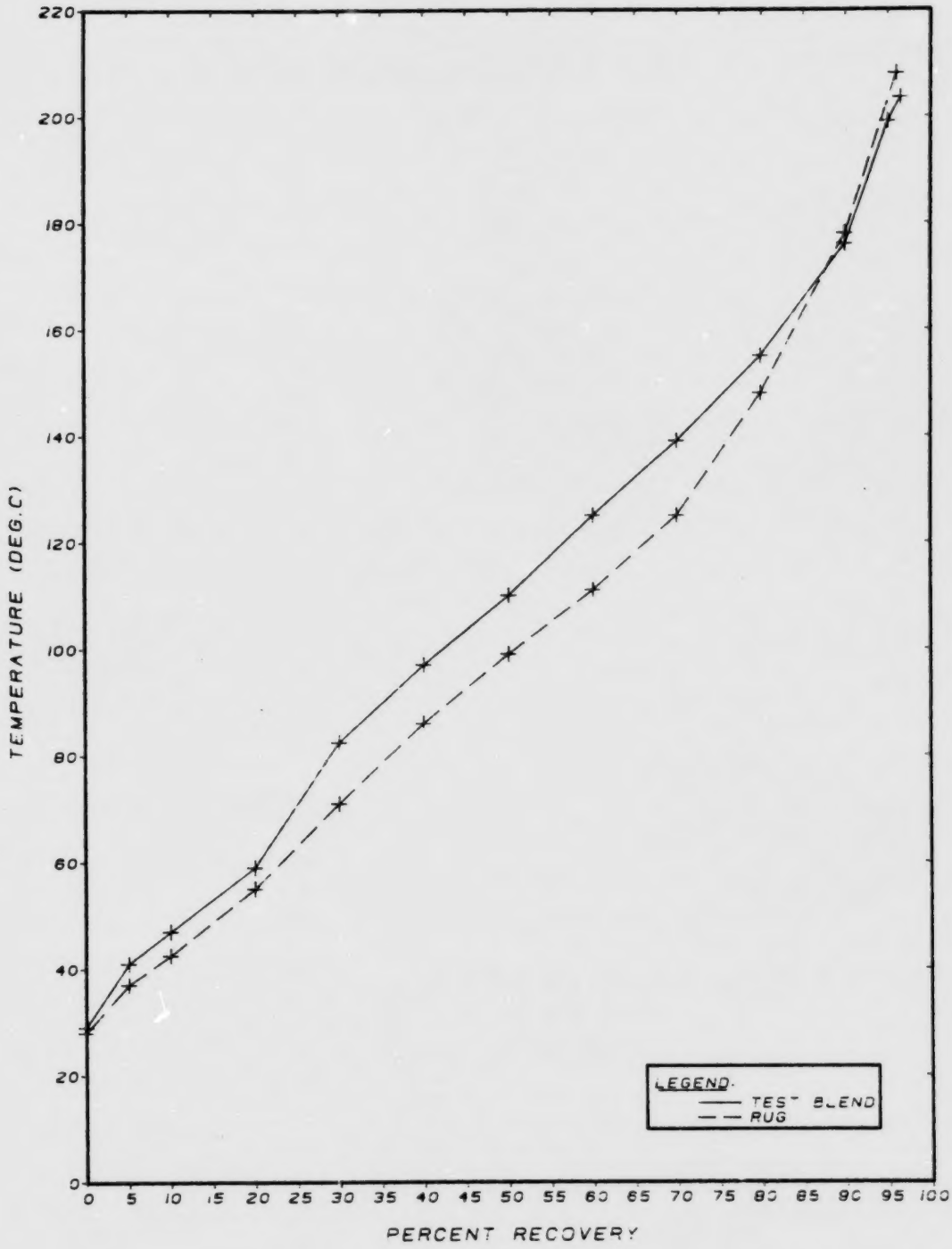


Figure 4: ASTM Distillation Curves for December 19, 1984

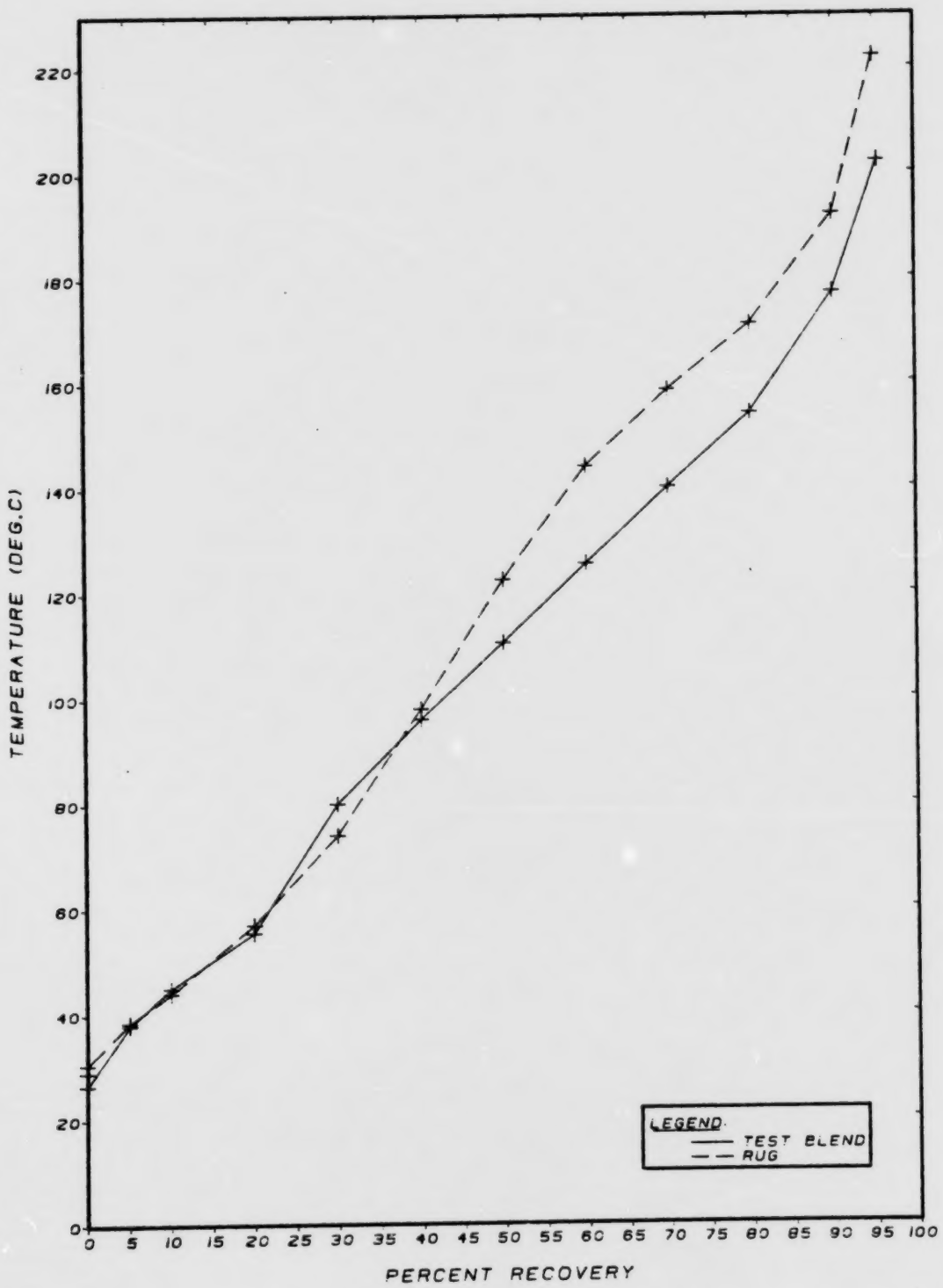


Figure 5: ASTM Distillation Curves for January 17, 1985

3.2 Fleet Energy Consumption

During the first five months of the demonstration, the RUG fleet travelled approximately 127,000 km and consumed 26,000 L. The test blend fleet travelled approximately 175,000 km and consumed 34,000 L of fuel.

To obtain meaningful fleet energy consumption data the matching fleets were chosen such that their driving cycles were comparable. All the matching vehicles were operated in the City of Winnipeg.

Figure 6 illustrates the percent difference in specific energy consumption for the 22 matched test blend and RUG fueled vehicle types. The test blend fleet used 11.2% more energy, on average, than the matching RUG fueled vehicle types. This is significant at the 90% confidence level. Results for the matched vehicle types and unmatched vehicles are presented in Tables VIII and IX.

One must bear in mind that many variables influence the fuel economy performance of an operating fleet. These include driving style, vehicle condition, manufacturing variability and modifications to engine and fuel systems. Another factor that could possibly play a large role is the driver and the psychology involved in operating a vehicle on a "foreign" fuel. People generally will not accept something new unless they are convinced of its equality or superiority. Therefore it is not always easy to obtain objective data, e.g. a driver might leave his methanol-fueled vehicles idling longer than 5 minutes during a break because he believes it won't start if he turns it off. He undoubtedly would believe a gasoline engine would start under the same conditions. The result would be higher energy consumption for methanol-fueled vehicles. For these reasons, the fleet data should be regarded more as a check on dynamometer data than as true, repeatable values.

Tachographs were installed in the three Pontiac 6000's (vehicle type O). Specific energy consumption for the test blend and the RUG fueled vehicles were comparable. This was due to similar driving cycles.

The energy consumptions for vehicle types R and S are much higher for the test blend vehicles compared to their matching RUG fueled counterparts. To help identify the source of this anomaly, tachographs will be fitted to these vehicles to determine if the driving cycles are comparable.

3.3 Material to Fuel Compatability

This test is currently in progress. Results will be made available in the final Phase II report.

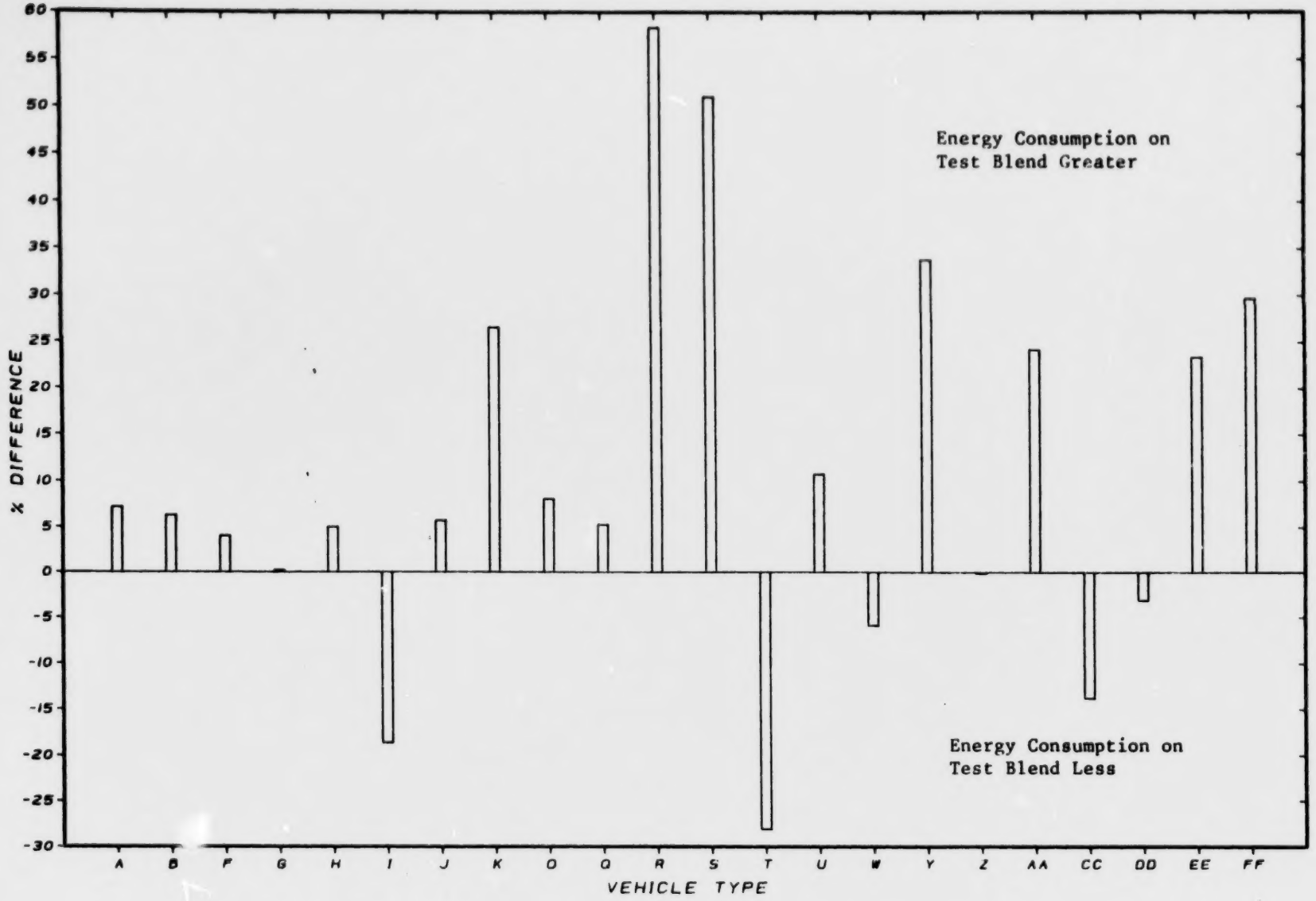


Figure 6: Difference in specific energy consumption for matched test blend and RUG - Fueled Type Vehicles

Table VIII: Fleet Specific Energy Consumptions for Matched Test Blend and RUG Fueled Vehicles September 4, 1984 to February 15, 1985

Vehicle Type	Mean Specific Energy Consumption (MJ/100 km)		
	RUG	Test Blend	Difference
A	464.11	497.38	-38.27
B	408.42	434.12	-25.70
F	600.00	624.03	-24.03
G	382.95	383.76	-0.81
H	532.37	558.91	-26.54
I	468.46	381.26	87.20
J	465.99	492.63	-26.64
K	427.33	540.57	-113.24
O	335.28	362.33	-27.05
Q	402.41	423.56	-21.15
R	807.65	1278.89	-471.24
S	643.60	971.82	-328.32
T	639.11	459.58	179.53
U	419.18	464.11	-44.93
W	920.79	866.72	54.07
Y	878.95	1175.71	-296.76
Z	778.24	777.22	1.02
AA	706.70	877.44	-170.74
CC	1198.16	1032.95	165.21
DD	1285.36	1245.40	39.96
EE	1078.22	1330.23	-252.01
FF	1147.28	1487.56	-340.28
Average	681.39	757.55	-76.16
Significance Level			>90

Table IX: Energy Consumptions of the Unmatched Test Blend Vehicles

Vehicle Type	Mean Specific Energy Consumption (MJ/100 km)
C	323.89
D	--
E	302.18
L	577.96
M	511.96
N	--
P	431.93
V	406.19
X	674.06
BB	602.07

3.4 Engine Dynamometer Testing

Due to delays in the delivery of certain components required for the test, engine dynamometer testing could not be completed at the time of writing. Results will be available in the final Phase II report.

3.5 Chassis Dynamometer Testing

A total of ten tests were conducted on the chassis dynamometer. The results, expressed as percent differences, are shown in Figures 7 and 8. Tabulated fuel and energy consumption data are presented Tables X to XIII (refer to Appendix III for statistical treatment).

Since chassis dynamometer testing eliminated many of the uncontrolled variables that may occur in fleet comparisons, including weather, terrain, road conditions, driving style, vehicle conditions, optional equipment, manufacturing variability and load, a valid assessment of specific energy consumption differences attributable to the different fuels could be obtained. Test repetitions ensure a high degree of precision.

The paired sample t-test at 48 km/h showed that there was no significant difference in specific energy consumption. On average, the ten vehicles tested used 1.1% more energy per unit distance running on the test blend than they did operating on RUG. The tests at 48 km/h employs high loads so that hard acceleration is the simulated effect. Under these conditions, only two vehicles were more energy efficient on the test blend fuel.

The same statistical analysis of the 88 km/h test showed that there was no significant difference in energy consumption at a 90% confidence level despite the fact that six out of ten vehicles operated more energy efficiently on test blend fuel. The average of the ten tests was 0.6% greater specific energy consumption on test blend. This test employs a relatively low load so that normal highway driving is the simulated effect.

3.5.1 Aldehyde Emissions

At present, aldehyde emissions from automobile exhaust are an unregulated emission. It is generally believed that there will be an increase in aldehyde emissions with the introduction of low methanol blend gasolines. Therefore, a test method for sampling, identifying and quantifying aldehyde emissions was developed at ITC for the Phase II demonstration.

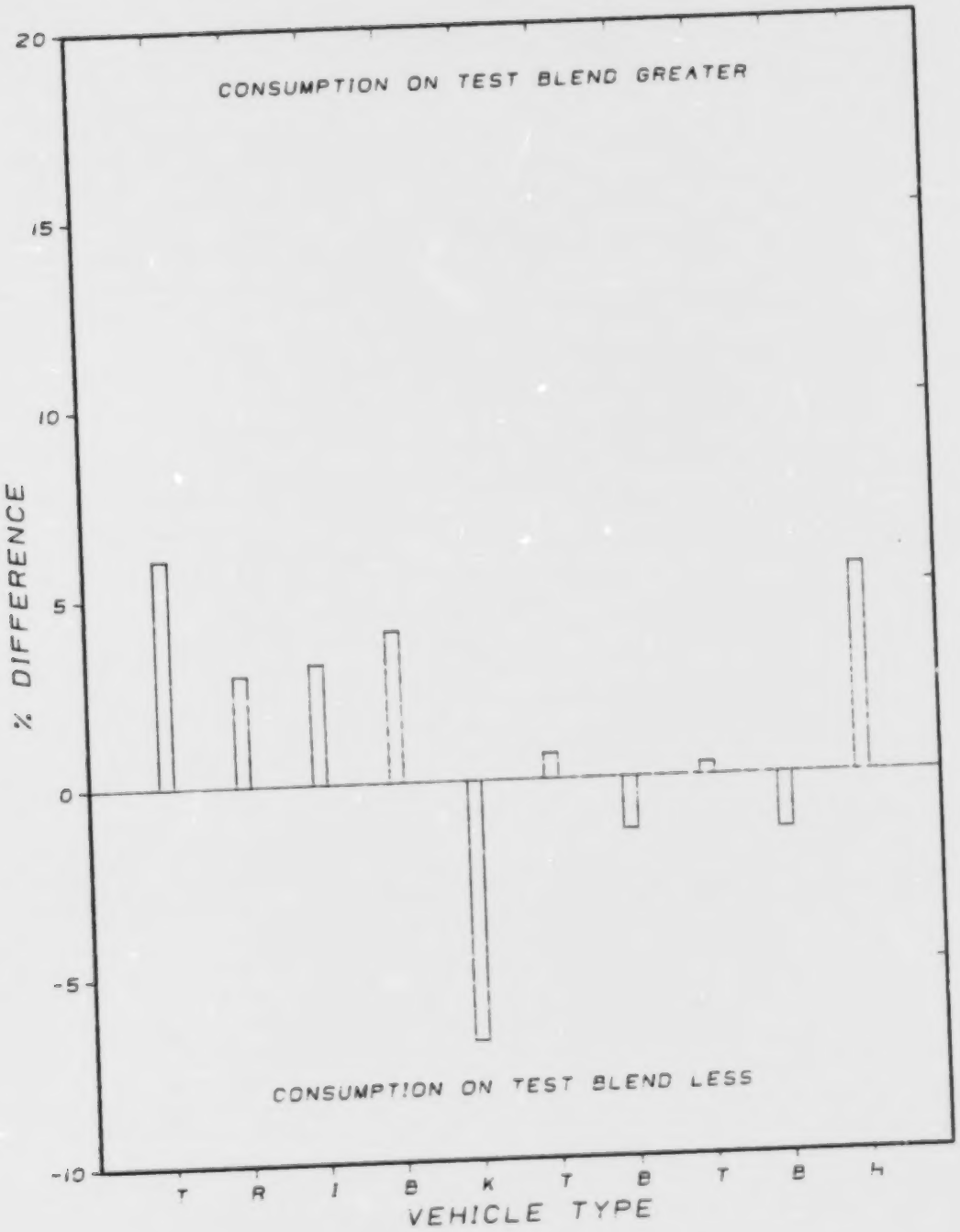


Figure 7: Difference in Specific Energy Consumption on the Chassis Dynamometer at 48 km/h

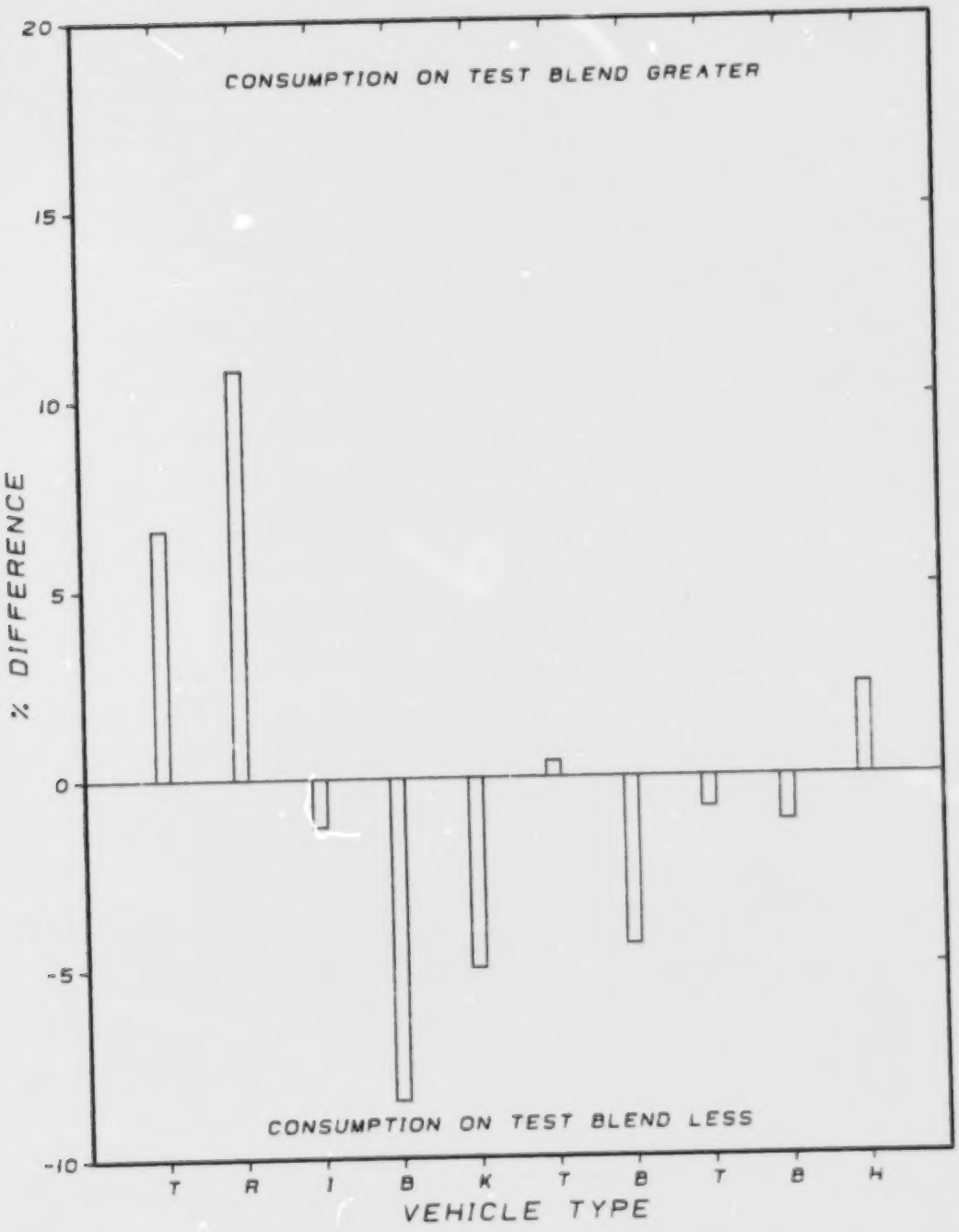


Figure 8: Difference in Specific Energy Consumption on the Chassis Dynamometer at 88 km/h

Table X: Specific Fuel Consumption of Matched Test Blend M5 and RUG Fueled Vehicles on the Chassis Dynamometer at 48 km/h

Test Number	Vehicle Type	Specific Fuel Consumption, L/100 km		
		RUG	Test Blend	Difference
1	T	23.55	24.92	-1.37
2	R	29.66	30.00	-0.34
3	I	33.48	34.04	-0.56
4	B	14.98	15.36	-0.38
5	K	30.31	27.77	2.54
6	T	27.49	27.65	-0.16
7	B	19.86	20.24	-0.38
8	T	25.99	26.89	-0.90
9	B	18.31	18.36	-0.05
10	H	21.79	23.29	-1.50
Average		24.54	24.85	-0.31
Significance Level				<90

Table XI: Specific Energy Consumption of Matched Test Blend and RUG Fueled Vehicles on the Chassis Dynamometer at 48 km/h

Test Number	Vehicle Type	Specific Energy Consumption, MJ/100 km		
		RUG	Test Blend	Difference
1	T	786.70	834.06	-47.36
2	R	985.90	1014.71	-28.81
3	I	1114.27	1149.70	-35.43
4	B	498.25	518.31	-20.06
5	K	1003.15	934.37	68.78
6	T	923.49	929.57	-6.08
7	B	687.67	678.18	9.49
8	T	893.98	896.76	-2.78
9	B	622.61	613.61	9.00
10	H	738.15	778.50	-40.35
Average		825.42	834.78	-9.36
Significance Level				<90

Table XII: Specific Fuel Consumption of Matched M5 and RUG Fueled Vehicles on the Chassis Dynamometer at 88 km/h

Test Number	Vehicle Type	Specific Fuel Consumption, L/100 km		
		RUG	Test Blend	Difference
1	T	12.25	13.03	-0.78
2	R	14.07	15.31	-1.24
3	I	11.46	11.15	+0.31
4	B	8.97	8.09	+0.88
5	K	9.83	9.18	+0.65
6	T	10.17	10.20	-0.03
7	B	8.24	8.14	+0.10
8	T	10.03	10.26	-0.23
9	B	9.45	9.50	-0.05
10	H	7.91	7.92	-0.01
Average		10.24	10.28	-0.04
Significance Level				<90

Table XIII: Specific Energy Consumption of Matched M5 and RUG Fueled Vehicles on the Chassis Dynamometer at 88 km/h

Test Number	Vehicle Type	Specific Energy Consumption, MJ/100 km		
		RUG	Test Blend	Difference
1	T	409.21	436.17	-26.96
2	R	467.47	517.90	-50.43
3	I	381.44	376.61	4.83
4	B	298.27	272.96	25.31
5	K	325.26	309.01	16.25
6	T	341.69	343.08	-1.39
7	B	285.52	272.91	12.61
8	T	345.02	342.14	2.88
9	B	321.34	317.48	3.86
10	H	258.35	264.55	-6.20
Average		343.36	345.28	-1.92
Significance Level				<90

In addition to exhaust gas samples at standardized load conditions, ambient air samples from the dynamometer cell were also taken for aldehyde analysis before and after each chassis dynamometer run. Results are presented in Tables XIV to XVI. The definitions for the C_1, C_2, ... C_7 carbonyls are as follows:

C_1 - Formaldehyde

C_2 - Acetaldehyde

C_3 - Acetone, propanal, propenal

C_4 - Crotenal, methyl-ethyl ketone, butyral

C_5 - Valeral, methyl-n-propyl ketone, diethyl ketone

C_6 - Methyl-i-butyl ketone

C_7 - Methyl-n-amyl ketone

From the tables, the following observations were made:

1) Ambient air within the dynamometer test chamber had detectable amounts of aldehydes present at the start of tests and generally these increased over the period of testing. This may have interfered with the emissions data collected from the vehicle exhausts.

2) Variations in the aromatics content of the RUG also had an effect on the aldehyde levels in the emissions.

3) Generally, it was felt that the aldehyde emissions were no worse with the test blend than with RUG.

3.6 Driving Cycle Tests

3.6.1 Fuel Economy Measurement

Testing was not completed due to late delivery and electrical malfunctions in the fifth wheel instrumentation and due to the onset of fall/winter weather conditions. Testing will be completed during the summer of 1985.

Table XIV: Aldehydes in Ambient Air Samples Before and After Chassis Dynamometer Testing

(These results are for ambient air samples taken within the dynamometer test cell before the serie of runs on each vehicle and after the series of runs on each vehicle)

Condition	Test Number	Vehicle Type	C_1	C_2	C_3	C_4	C_5	C_6	C_7	Benzaldehyde	Tolualdehyde
Before	3	I	0.12	0.10	0.22						
Testing	5	K	0.05	0.09	0.46			0.06			
	6	T	*		1.04						0.08
	7	B	0.20	0.14	0.66	*	*	*	*	*	
	8	T			0.13			*			
	9	B	0.22		0.23		*	*		*	
After	3	I	0.06	0.10	0.40						0.03
Testing	5	K	*		0.47						
	6	T	0.08	0.08	2.02	*			*	*	0.73
	7	B	0.25	0.23	0.83			*		*	*
	8	T	0.13	0.08	*			*		*	
	9	B	0.34		0.37		*	*		*	

Results are reported as mg/L

* Aldehydes identified but not quantified.

Table XV: Aldehyde in Exhaust Emissions from Chassis Dynamometer Testing at 48 km/h

Fuel	Test Number	Vehicle Type	C_1	C_2	C_3	C_4	C_5	C_6	C_7	Benzaldehyde	Tolualdehyde
Test	3	I	0.26	0.09	0.34			0.02			
Blend	5	K		0.06	0.51	*			*	0.05	
	6	T	0.78	0.27	1.07	0.09	*			0.01	0.05
	7	B		0.16	1.27	*	*	*	*	*	*
	8	T		0.10	0.21	0.05	*	*	*	*	
	9	B	0.14	0.11	0.27	*		*		*	
RUG	3	I	0.19	0.10	0.49			*		*	
	5	K			0.46						
	6	T	0.63	0.21	1.28	0.08			*	0.03	0.31
	7	B		0.24	0.75	*	*	*	*	*	*
	8	T		0.23		0.07	*	*	*	*	*
	9	B	0.25	0.10	0.51			*			

Results are reported as mg/L

* Aldehydes identified but not quantified.

Table XVI: Aldehyde in Exhaust Emissions from Chassis Dynamometer Testing at 88 km/h

Fuel	Test Number	Vehicle Type	C_1	C_2	C_3	C_4	C_5	C_6	C_7	Benzaldehyde	Tolualdehyde
Test	3	I	0.56	0.14	0.56	0.03		*		0.11	
Blend	5	K	1.08	0.43	0.87		0.09	*	*	0.27	
	6	T	1.41	0.31	1.21	0.11			*	0.10	0.06
	7	B		0.22	1.24	*		*	*	*	*
	8	T	2.81	0.43	0.28	0.07	*		*	0.06	*
	9	B	0.08	0.08	0.30	*		*		*	
RUG	3	I	0.40	0.14	0.44	0.04		*		*	
	5	K	0.96	0.41	0.87	0.22		0.04		0.08	
	6	T		0.26	1.30	0.09	*			*	0.35
	7	B		0.16	0.68	*	*	*	*	*	*
	8	T		0.41	0.55	0.04	*	*	*	0.08	*
	9	B	0.24	0.12	0.40	*	*	*		*	

Results are reported as mg/L

* Aldehydes identified but not quantified.

3.6.2 Driveability Comparison

Ten tests were conducted on the ITC Cold Start Driveability Test Route. Results are presented in Table XVII and Figure 9. The test procedure is outlined in Appendix II.

Test numbers 1 to 6 and 8 consisted of testing one car on the two fuels. These vehicles were tested three to five times on the test route on one fuel. Then the gas tank was drained, the other fuel added and three to five more tests were conducted.

Test numbers 7, 9 and 10 consisted of testing two matching cars on the two fuels. Three to five test runs were conducted using a vehicle normally operating on the test blend fuel. Following this, the matching RUG fueled counterpart was tested three to five times.

The test blend fuel evaluated for the first five tests was the summer grade fuel. The test blend fuel evaluated for test numbers 6 to 10 was the vapour pressure adjusted test blend fuel.

Based on the final results of the first nine tests there was no significant difference in demerits at the 90% confidence level. The tenth test vehicle was not included in any of the statistical analyses due to the extreme difference in temperatures for the two series of tests.

More testing will be conducted for the balance of the demonstration so that a sizeable database on driveability testing can be compiled.

3.7 Fleet Driveability

The driveability sheets were filled out by vehicle operators and submitted to ITC for data analysis. The data were organized monthly and are presented in Figures 10 to 14.

The first four questions on the driveability questionnaire are subjective in nature. They allow the driver to give some personal input into the questionnaire. The demerits are higher for the test blend fleet for the first four months of the demonstration. The difference in demerits between the test blend fleet and the RUG fleet was less pronounced in January. This may be attributed to the increase in vapour pressure of the test blend fuel.

Table XVII: ITC Cold Start Driveability Test Route Results

Test Number	Vehicle Type	Fuel	Fuel Vapour Pressure (kPa)	Ambient Temp.	Relative Humidity	Total Weighted Demerit
1	O	RUG	80	9.0	82	13
		Blend	63	2.0	90	12
2	Q	RUG	87	-10.5	79	8
		Blend	63	0.6	89	6
3	I	RUG	87	-3.3	90	16
		Blend	63	-0.3	87	25
4	A	RUG	87	-4.7	92	12
		Blend	59	-5.0	80	50
5	T	RUG	93	-10.5	76	58
		Blend	59	-2.6	92	36
6	D	RUG	98	-11.4	86	7
		Blend	91	-14.5	77	10
7	U	RUG	98	-10.1	88	1
		Blend	91	-13.7	77	2
8	E	RUG	91	-11.0	93	54
		Blend	91	-10.3	86	44
9	O	RUG	90	-25.0	71	38
		Blend	85	-31.6	60	54
10	T	RUG	86	-22.5	69	120
		Blend	88	-7.5	87	41
Significance Level (Tests 1 to 9)						<90

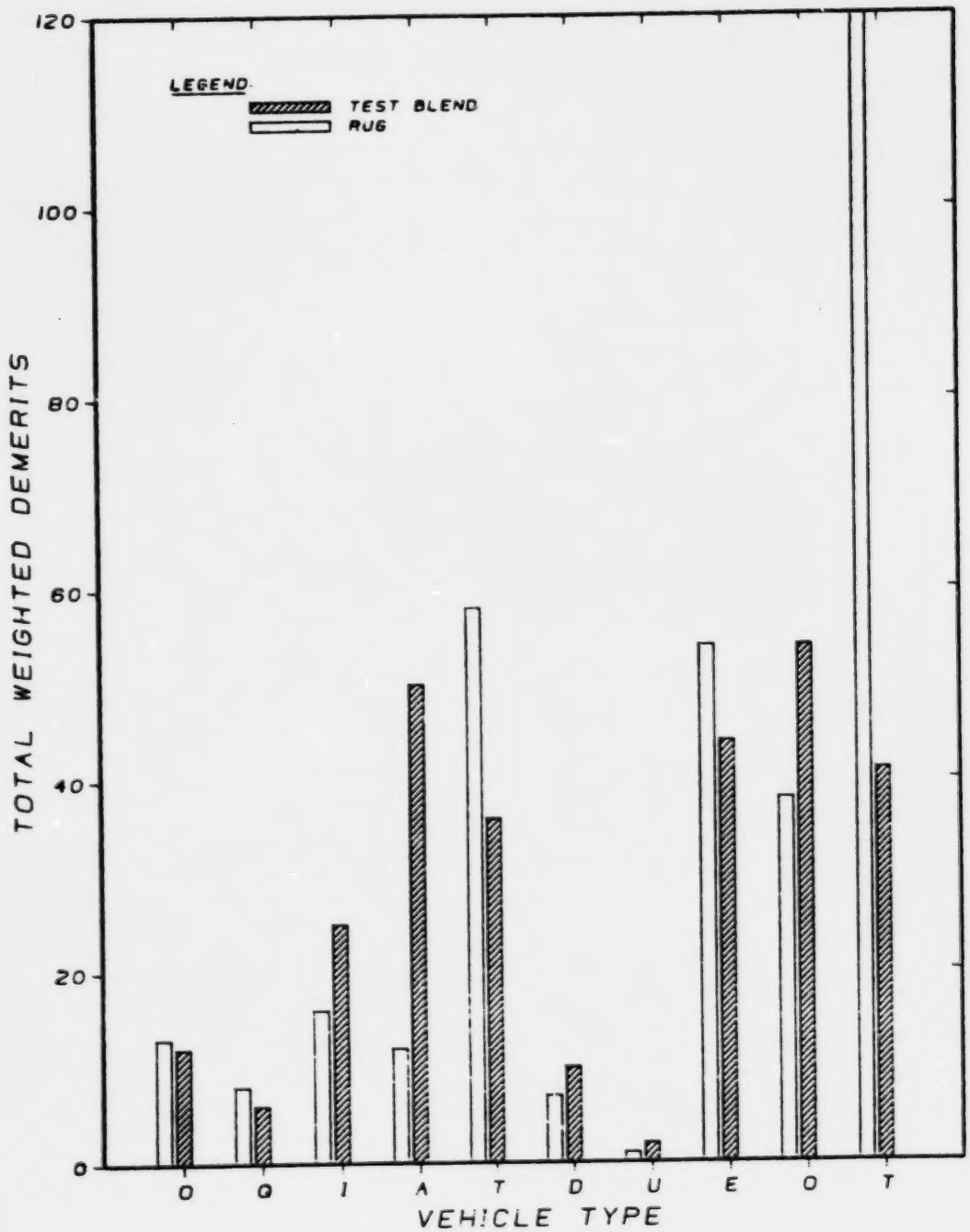


Figure 9: ITC Cold Start Driveability Test Route Results

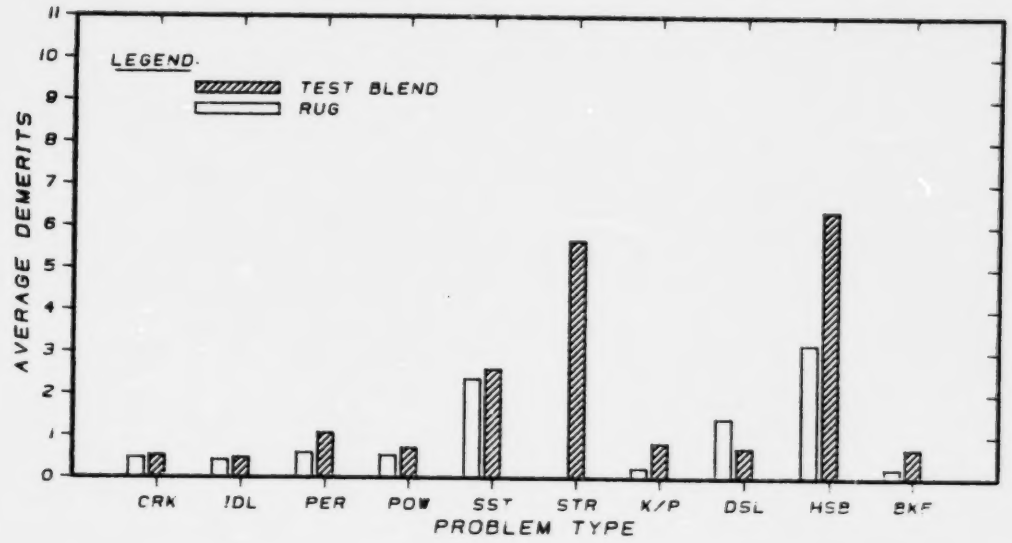
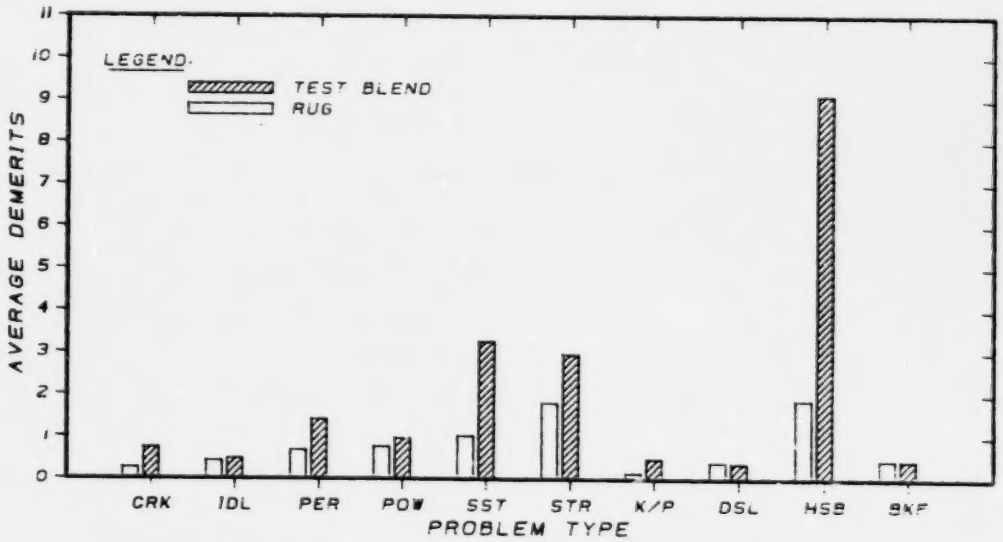


Figure 10: Fleet Driveability Results for September, 1984



PROBLEM TYPE CODES:

CRK - Cranking time to start
IDL - Engine idling
PER - Overall performance
POW - Power
SST - Stalling after starting
STR - Stalling in traffic
K/P - Knock/Pinging
DSL - Dieseling
HSB - Hesitation, Stumbling, Bucking
BKF - Backfiring

Figure 11: Fleet Driveability Results for October, 1984

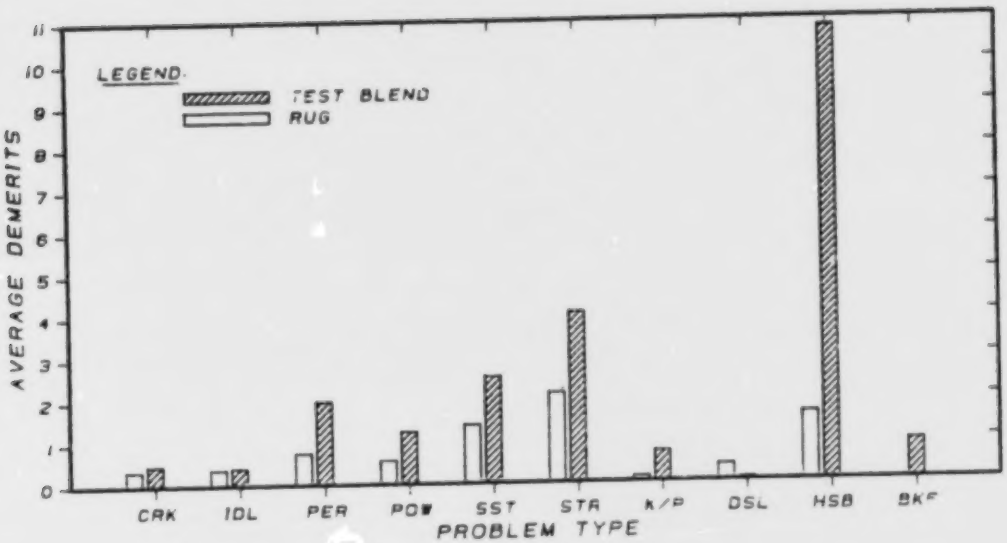
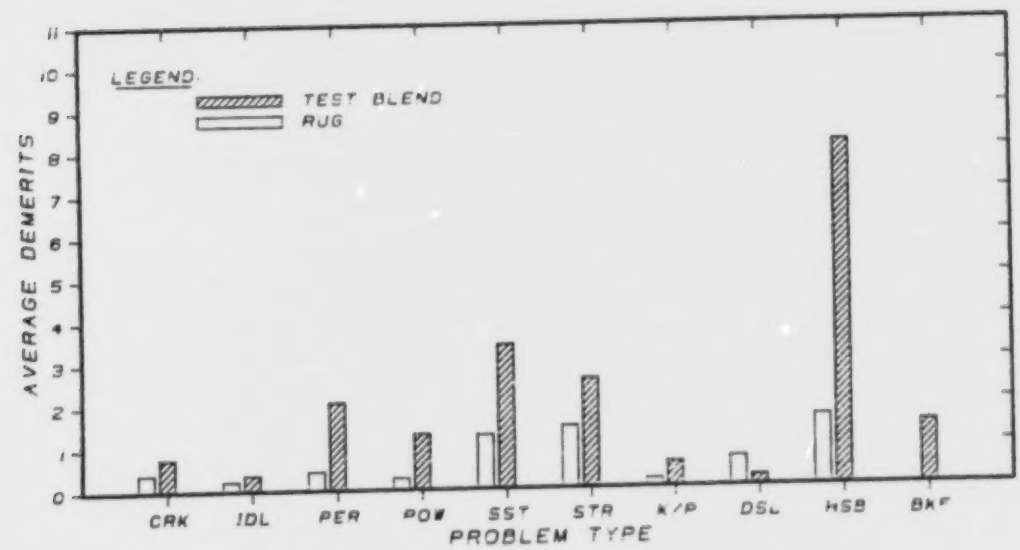


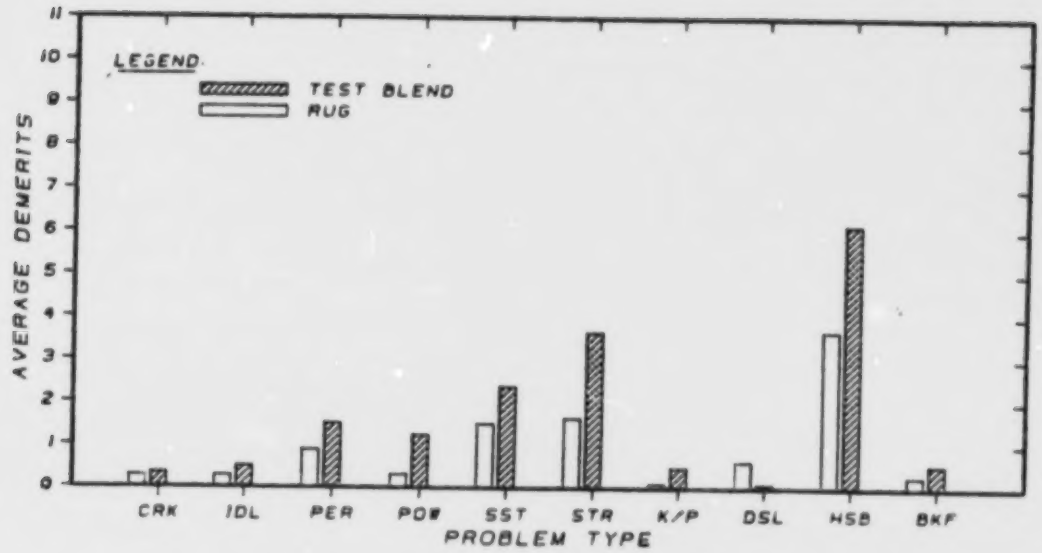
Figure 12: Fleet Driveability Results for November, 1984



PROBLEM TYPE CODES:

CRK - Cranking time to start
IDL - Engine Idling
PER - Overall performance
POW - Power
SST - Stalling after starting
STR - Stalling in traffic
K/P - Knock/Pinging
DSL - Dieseling
HSB - Hesitation,Stumbling,Bucking
BKF - Backfiring

Figure 13: Fleet Driveability Results for December, 1984



PROBLEM TYPE CODES

CRK - Cranking time to start
IDL - Engine idling
PER - Overall performance
POW - Power
SST - Stalling after starting
STR - Stalling in traffic
K/P - Knock/Pinging
DSL - Dieseling
HSB - Hesitation, Stumbling, Bucking
BKF - Backfiring

Figure 14: Fleet Driveability Results for January, 1985

Questions six to ten ask the driver for actual driveability fault occurences. There were more demerits reported by test blend drivers as compared to RUG drivers for:

- stalling after starting
- stalling in traffic
- knocking/pinging
- hesitation, stumbling, bucking
- backfiring

However, the differences were less pronounced in January. RUG drivers reported more dieseling occurrences compared to the test blend drivers.

The results of five test blend vehicle questionnaires were not used in the data analysis, because the demerits given the vehicle by the operator exceeded 100 in most cases. These vehicles were investigated and found not to have driveability faults as serious as the operators reported.

An in depth analysis of the driveability data was carried out. The results are tabulated in Tables XVIII and XIX. The total average demerits for the RUG fleet were significantly less than the demerits for the test blend fleet, for the first four months (September to December, 1984). The results for the two fleets in January are comparable (10.0 for RUG and 14.6 for test blend). This result was directly attributable to the increase in the vapour pressure of the test blend fuel from 59 to >90 kPa.

The percentage of RUG drivers reporting was about 45 to 50%. The percentage of test blend drivers is about 55 to 60% +. (It is most probable that all significant problems were brought to our attention).

It is interesting to note that the average demerits from the RUG fleet are relatively consistent even though there was a drastic decrease in ambient temperature. This indicates that fuel quality can be modified for different weather conditions/regions to give relatively the same driveability demerits.

The driveability results were also analyzed with respect to matched vehicle types and are presented in Figure 15. Overall there are more driveability demerits for the test blend fleet. However, vehicle types H, I, D, CC, EE had comparable and better performance on the test blend.

Table XVIII: Fleet Driveability Results (RUG)

	Sep/84	Oct/84	Nov/84	Dec/84	Jan/85
% Reporting	30	53	69	43	47
% of Sheets Returned with No Faults	27.3	47.5	48.8	63.4	48.2
Average Demerits of the Fleet	9.3	8.2	7.5	6.9	10.0
Fuel Vapour Pressure (kPa)	80	87	93	79	93*
Mean Monthly Temperature (°C)	+10.6	+6.4	-4.9	-17.6	N/A

Table XIX: Fleet Driveability Results (Test Blend)

	Sep/84	Oct/84	Nov/84	Dec/84	Jan/85
% Reporting	39	46	65	56	60
% of Sheets Returned No Faults	36.6	28.3	21.1	20.8	29.6
Average Demerits of the Fleet	16.8	19.8	23.4	24.6	14.6
Fuel Vapour Pressure (kPa)	64	63	59	59/87	91
Mean Monthly Temperature (°C)	+10.6	+6.4	-4.9	-17.6	N/A

N/A - Not available at time of writing

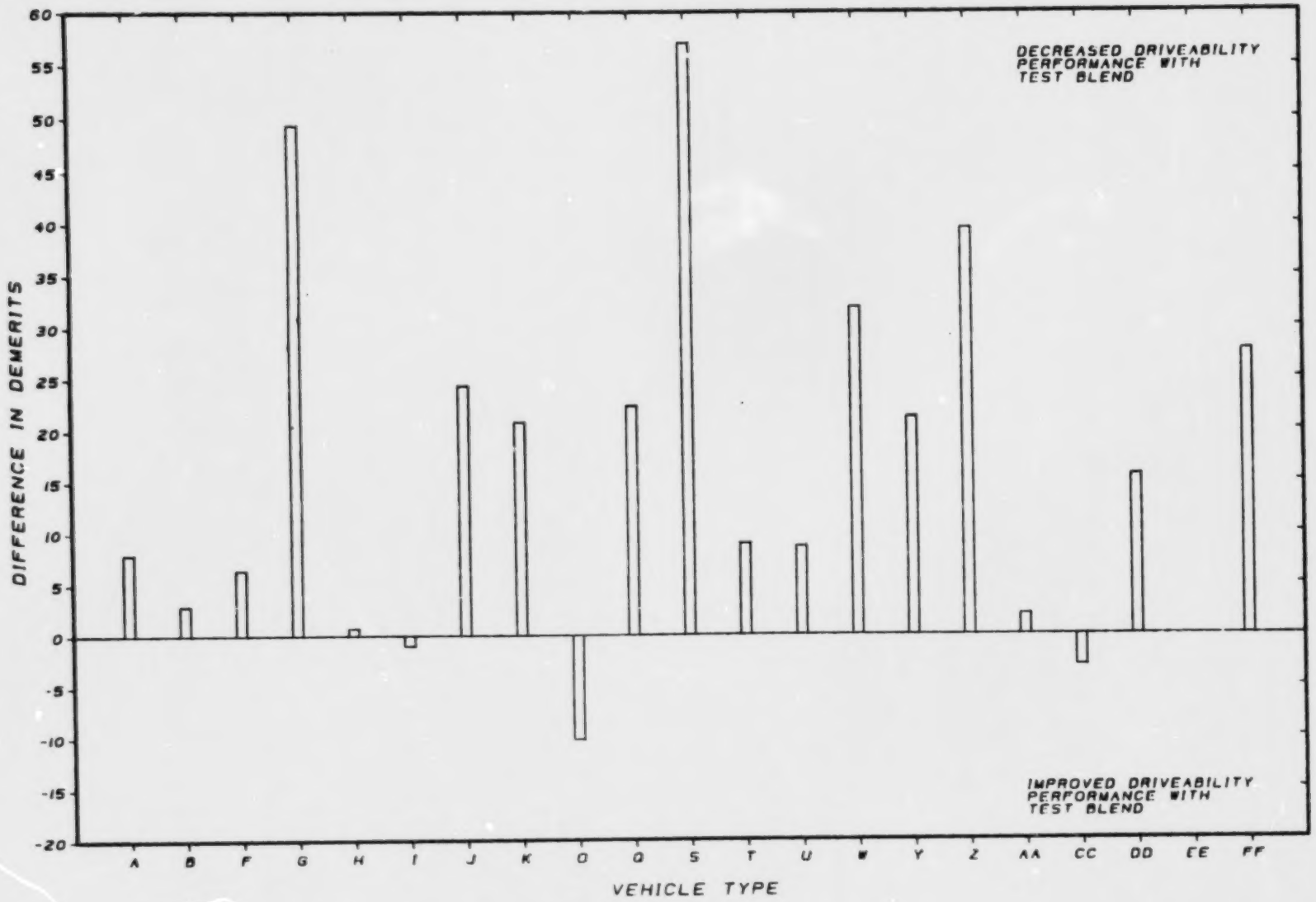


Figure 15: Difference in Demerits for Matched Test Blend and RUG Fueled Vehicles

The weekly driveability questionnaire was modified in January 1985 so that driveability faults can be related to engine temperature. An eleventh question was added which asks the driver "when do the majority of problems occur"? Of the questionnaires returned the majority of problems occurred within the first five minutes of vehicle start up.

3.8 Oil Analysis and Maintenance

The oil used for this study was a 5W30 weight oil supplied by PetroCan. Results are not presented since there are insufficient data at the time of writing. All results will be presented in the final report.

No maintenance problems associated with the test blend fuel were reported for the period September 1984 to January 1985.

3.9 Failure Analysis

No cases of engine breakdowns were reported since the start of the demonstration.

4. CONCLUSIONS

The uniformity of bulk blending reduced the variation experienced with pump blending in Phase I and allowed for better comparison with regular unleaded gasoline.

Specific energy consumption data from chassis dynamometer test work is more reliable than fleet operation for fuel performance comparison purposes.

Ten tests on the chassis dynamometer simulating hard acceleration at 48 km/h were conducted. On average, the test blend vehicles used 1.1% more energy per unit distance than the RUG vehicles. This result was not statistically significant.

The same test operated at 88 km/h, simulating normal highway driving, showed no statistically significant difference in energy consumption between the test blend and regular unleaded fueled vehicles. On average, the test blend vehicles used 0.6% less energy per unit distance.

The 22 matching test blend vehicle types used 11.2% more energy than their RUG fueled counterparts.

Results from the ITC Cold Start Driveability Test Route, for the nine vehicles tested, showed no statistically significant difference in demerits (at 90% confidence) over the temperature range of +10°C to -32°C.

A test method for sampling, identifying and quantifying aldehyde emissions was developed. Generally, it was felt that the aldehyde emissions from chassis dynamometer were no worse with the test blend than with the RUG.

No maintenance problems associated with the test blend fuel were reported for the period September 1984 to January 1985.

Due to problems with the fuels more data are required from both the driveability questionnaire and the controlled driveability testing.

Tachographs are useful in monitoring the driving cycles and comparing the energy consumptions of matched vehicle types.

5. RECOMMENDATIONS

It is recommended that the fleet test demonstration continue for eighteen months so that two summers plus one more winter of data can be collected.

APPENDIX I

CGSB Draft Specifications for Unleaded Oxygenated Automotive Gasoline

APPENDIX 1

DRAFT
84-5-15

CAN2-3.XXM84

CANADIAN GENERAL STANDARDS BOARD

OXYGENATED AUTOMOTIVE GASOLINE, UNLEADED

INFORMATION DOCUMENT

1. SCOPE

1.1 This information document applies to two types of oxygentated automotive gasoline prepared by blending alcohol(s) containing no more than four carbon atoms and/or methyl-t-butyl ether (MTBE) or t-amyl-methyl ether (TAME) into a selected gasoline to which no lead or phosphorus compounds have been added. The resultant blend must meet the detailed reqirements of this document. These fuels are suitable for use in spark ignition engines equipped with emission control systems which require or permit the use of unleaded gasoline.

1.2 This document is of necessity incomplete due to the lack of suitable test methods and control parameters for some properties. In recognition of existing need, this document is issued to provide guidance until work on the standard is complete.

1.3 The user should be aware of the more detailed properties of the particular fuel which may affect fuel system material compatibility, paints and finishes, and vehicle performance.

2. APPLICABLE PUBLICATIONS

2.1 The following publications are applicable to this document:

2.1.1 American Society for Testing and Materials (ASTM)

Annual Standards for Petroleum Products and Lubricants Volumes 03.05, 05.01, 05.02, 05.03, 06.03, and 15.05.

E-29 - Recommended Practice for indicating which place of figures are to be considered significant in specified limiting values.

2.2 Reference to the above publications is to the latest issues. The source of these publications is shown in the Notes Section.

3. CLASSIFICATION

3.1 The oxygenated gasoline shall be supplied in the following types and grades:

3.1.1 Types

Type 1
Type 2

3.1.2 Grades

A. (Summer)
B. (Intermediate 1)
C. (Intermediate 2)
D. (Winter)

4. GENERAL REQUIREMENTS

4.1 The fuel shall consist of a single clear phase and be free of suspended matter.

4.2 The fuel shall be colored as follows:

Type 1 - Green
Type 2 - Undyed

Type 1 oxygenated gasoline shall contain sufficient green dye to match a standard sample of water white mineral spirits dyed with 1.0 kg/1000 m^3 of 1, 4-diisopropylaminoanthraquinone and 1.25 kg/1000 m^3 of p-diethylaminoazobenzene.

Type 2 oxygenated gasoline shall not contain dye.

4.3 The oxygenated gasolines specified may contain additives designed to improve their characteristics. These may include metal deactivators, oxidation inhibitors, corrosion and rust inhibitors, icing inhibitors and detergents. With oxygenated gasolines so formulated, supplementary additives are not normally required.

5. DETAIL REQUIREMENTS

The finished fuel shall comply with the following detail requirements. The limits specified are absolute; they are not subject to correction for tolerance of test methods.

5.1 Octane Quality.

5.1.1 Type 1 Oxygenated Gasoline - The Antiknock Indices (defined as half the sum of the Research (R) and Motor (M) octane numbers ie. (R+M)/2) shall not be less than the minimums allowed in Table 1: Schedule of Seasonal and Geographical Minimum Antiknock Indices.

5.1.2 Type 2 Oxygenated Gasoline - The Motor Octane number (M) and the Antiknock Indices (defined as half the sum of the Research (R) and Motor (M) octane number ie (R+M)/2) shall not be less than the minimums allowed in Table 2: Schedule of Seasonal and Geographical Minimum Antiknock Indices.

5.1.3 Motor Octane Numbers and Antiknock Indices shall be rounded off to the nearest tenth. Antiknock Indices ending exactly in 5 in the second decimal, shall be rounded to the nearest even tenth number; for example, round 90.55 and 90.65 to 90.6.

5.1.4 Research Octane Number shall be determined by ASTM D 2699.
Motor Octane Number shall be determined by ASTM D 2700.

		TYPE 1 & 2	ASTM TEST METHOD & NOTES
5.2	Oxygen Content, % mass, Max.	3.7	See (a) 11.2 and 11.2.1
5.2.1	Methanol Content, % Vol, Max.	5.0	See (b) 11.2 and 11.2.1
5.2.2	Lead Content, mg/L, Max.	13	D 3237
5.2.3	Phosphorus Content, mg/L, Max.	1.3	D 3231
5.2.4	Manganese Content, mg/L, Max.	18	D 3831
5.2.5	Sulphur, % mass, Max.	0.15	D 3120 (c)
5.3	Gum, Existent, mg/100 mL, Max.	5	D 381
5.4	Oxidation Stability (Induction Period) Minutes, Min.	240	D 525
5.5	Copper Corrosion, 3 h at 50° C., Max.	No. 1	D 130

a) Oxygen in the form of alcohols and/or ethers only.

b) Cosolvent(s) may be required with methanol blends but in all cases, total oxygen content must not exceed 3.7% mass.

c) Alternative test methods may be used as agreed upon by supplier and purchaser.

5.6 Volatility.

5.6.1 The four volatility grades of oxygenated gasoline listed in 3.1.2 shall conform to the requirements prescribed in Table 3: Volatility Characteristics of Gasoline Grades.

5.6.2 The seasonal and geographical distribution of the volatility grades shall conform to the schedule in Table 4: Schedule of Seasonal and Geographical Volatility Grades.

This schedule represents the time and place of use of the gasoline. Shipments intended for future use may anticipate this schedule.

6. SWELLING AND DETERIORATION OF PLASTICS AND ELASTOMERS

6.1 The oxygenated gasoline shall have no significant effect on these materials as used in automotive fuel systems, engines and in fuel storage and dispensing equipment. (See NOTES Section 11.2 and 11.3).

7. LOW TEMPERATURE PHASE STABILITY

7.1 The oxygenated gasoline shall be clear and bright and a single phase as follows:

A) At temperatures down
B) to -10°C.

C) At temperatures down
D) to -40°C.

(See NOTES Section 11.2 and 11.3).

8. METAL CORROSION

8.1 The oxygenated gasoline should have no significant corrosive effect on metallic compounds as used in vehicle fuel systems and in fuel storage and distribution systems. (See NOTES Section 11.2 and 11.3).

9. OXYGENATED COMPOUNDS

9.1 The oxgenated compounds used shall conform to the following requirements:

Copper Content, mg/L, Max.	0.1	D 1688
Total Acidity, (as acetic acid) mg/L, Max.	30	D 1613
Water, % mass, Max.	0.2	E 203 (d)
Denaturants in Ethanol, % Vol., Max.	5.0	(e) and 11.2
Chlorine Content, mg/kg, Max.	10.0	(f)

(d) Water content for ethanol shall not exceed 1.0% mass.

(e) Denaturants shall be hydrocarbon type in the gasoline boiling range.

(f) No generally accepted test procedures at this time - several methods available.

10. INSPECTION

10.1 Sampling - A sample of not less than four litres shall be provided and shall be obtained in accordance with ASTM D 4057. Oxygenated fuels are hygroscopic, and therefore, special care must be taken to avoid sample exposure to air.

11. NOTES

11.1 Options - The following options provided in this document should be specified in its application.

a. Type (par. 3.1.1)
b. Grade (par. 3.1.2)

11.2 Appropriate test methods are currently lacking in these areas, but test development work is underway.

11.2.1 A draft 3-GP-0 method for determining oxygenates in gasoline has been proposed.

11.3 Some guidance may be obtained by review of the ASTM Information Document on Gasohol (Motor Fuel containing 10% volume of Denatured Ethanol in Gasoline). See 2.1.1 and 11.4.

11.3.1 The Canadian General Standards Board Standard CAN2-3.5-M Gasoline, Automotive, Unleaded was used as the basis for this work and may be a helpful reference document.

11.4 The publications listed in par. 2.1.1 and 11.3 may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA., 19103, U.S.A.

11.5 The publication listed in par 11.3.1 may be obtained from the Canadian General Publishing Centre, Supply and Services Canada, Ottawa, K1A 0S9. Telephone (819)997-2560.

TABLE 1

SCHEDULE OF SEASONAL AND GEOGRAPHICAL MINIMUM ANTIKNOCK INDICES

TYPE 1 UNLEADED GASOLINE

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Coastal B.C. & Maritimes	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
Interior B.C., Alberta, Yukon N.W.T.	87.0	87.0	87.5	88.0	88.0	88.0	88.0	88.0	88.0	88.0	87.5	87.0
Saskatchewan	87.5	87.5	88.0	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.0	87.5
Manitoba & N.W. Ont.	88.5	88.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.0	88.5
Ontario (except N.W. Ont.) Quebec & Labrador	89.5	89.5	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	89.5

(Test Methods - ASTM D 2699 and D 2700)

TABLE 2

SCHEDULE OF SEASONAL AND GEOGRAPHICAL MINIMUM ANTIKNOCK INDICES

TYPE 2 UNLEADED GASOLINE

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Coastal B.C. & Maritimes	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
Interior B.C., Alberta, Yukon N.W.T.	83.0	83.0	83.5	84.0	84.0	84.0	84.0	84.0	84.0	84.0	83.5	83.0
Saskatchewan	84.0	84.0	84.5	85.0	85.0	85.0	85.0	85.0	85.0	85.0	84.5	84.0
Manitoba & N.W. Ont.	85.0	85.0	85.5	86.0	86.0	86.0	86.0	86.0	86.0	86.0	85.5	85.0
Ontario (except N.W. Ont.), Quebec & Labrador	86.5	86.5	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	86.5

(Test Methods - ASTM D 2699 and D 2700)

NOTE: Motor Octane Number shall be not more than 5.0 units lower than the minimum Antiknock Index

TABLE 3

VOLATILITY CHARACTERISTICS OF GASOLINE GRADES

GASOLINE VOLATILITY CLASS	REID VAPOUR PRESSURE (kPa) ASTM D323 (DRY METHOD) SEE NOTE	DISTILLATION TEMPERATURE (°C) PERCENT EVAP(		
		10	50 ASTM D86	9(
A	79 Max.	40-65	80-120	19(
B	86 Max.	60 Max.	75-117	19(
C	97 Max.	55 Max.	*70-113	18
D	69 Min. 107 Max.	50 Max.	*65-110	18

* Gasoline/Oxygenate blends, e.g. those containing only MTBE, with 50% points below 75°C need additives to avoid carburetor icing in susceptible vehicles.

NOTE: ASTM D 323 must be modified as outlined in the ASTM Information Document on Gasoho (Motor Fuel containing 10% volume of Denatured Ethanol in Gasoline), or later ASTM revision thereof. See 2.1.1 and 11.4.

TABLE 4

SCHEDULE OF SEASONAL AND GEOGRAPHICAL VOLATILITY GRADES

Geographic Area	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
I Coastal B.C. & Southern West	D	D	D	C	B	A	A	A	B	C	D	D
II Northern West	D	D	D	D/C	C/B	B	A	B	C	D	D	D
III Central	D	D	D	D/C	C/B	A	A	A	B/C	C/D	D	D
IV Southern	D	D	D	C	B	A	A	A	B	C	D	D
V NFLD. & N. Que.	D	D	D	D	C	B	A	A/B	B/C	D	D	D
VI Atlantic Coast	D	D	D	D	C	B	A	A	B	C	D	D
VII N.W.T. & Y.T.	D	D	D	D	C	B	B	B	C	D	D	D
VIII Arctic Coastal	D	D	D	D	D	C	C	D	D	D	D	D

NOTE: The approximate geographical areas are illustrated in Figure 1.

Figure 1.

The area breakdowns shown are based on average high temperature (Volatility) requirements and not laws and design data.

APPENDIX II

ITC/MRC Cold Start Driveability Test Route

and

Revised Fleet Survey Questionnaire

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ABSTRACT

This report explains the newly developed Industrial Technology Centre/Manitoba Research Council Cold Start Driveability Test Route and the revised Fleet Survey sheet. The test route is designed specifically to compare vehicle driveability using gasoline and the new M4.75 test fuel. Driveability is measured using a demerit system which allows statistical comparison between test run results using two different fuels. The test route uses public roads adjacent to the Industrial Technology Centre facilities in Winnipeg. A revised fleet survey questionnaire is also introduced which is designed to improve the quantity and quality of information received (as compared to the previously used questionnaire) from the regular fleet vehicle operators of the new M4.75 test fleet.

1. INTRODUCTION

The Industrial Technology Centre (ITC) has vast experience in the area of alternative fuels fleet testing. The ITC providing technical supervision, along with private companies and various levels of government have evaluated propane, gasohol (10% ethanol in 90% gasoline), neat methanol and a methanol/gasoline blend in various programs. These tests have examined key areas of concern including vehicle performance, fuel/materials compatibility, fuel/energy economy, exhaust emissions and vehicle driveability.

Commencing in August 1984, ITC, in conjunction with the Manitoba Department of Energy & Mines, Energy Mines and Resources Canada, the Motor Vehicles Manufacturers Association (MVMA), Manitoba Telephone System (MTS) and Canadian Methanol Canadien (CMC), will examine a methanol/isobutanol gasoline bulk blended fuel. The fuel consisting of 4.75% methanol, 4.75% isobutanol and 90.5% tailored regular unleaded gasoline (M4.75) will conform with the Canadian General Standards Board regional specifications for methanol containing gasoline blends.

For this project a method of evaluating and comparing vehicle driveabililty using the M4.75 blend and a control unleaded gasoline was required. A cold start driveability test route, similar to driveability test methods used by the Coordinting Research Counicl (CRC) of Atlanta, Georgia was developed.

The ITC test route uses public roads adjacent to the ITC administration and testing facility in Winnipeg, Manitoba. This report explains in detail the cold start driveability test route, test procedure, scheduling of tests and test evaluation using a demerit system and statistical analysis.

In addition, a revised Weekly Log Sheet has been developed for the fleet test. This sheet surveys the regular vehicle operators to obtain their subjective evaluation of vehicle driveability. The revised questionnaire is introduced as is the demerit schedule associated with it in Part II of this report.

A brief introduction to the fuel uses of methanol and an explanation of driveability is also given.

1.1 Methanol as an Automotive Fuel

Methanol is attractive as an alternative fuel in Canada because of abundant supply of natural gas, a primary feedstock for methanol production. Currently up to 90% of domestically produced methanol is exported.

Methanol can be utilized either as a neat fuel (which may contain varying amounts and types of additives to aid cold starting) in specially designed vehicles or as low level blends in gasolines for use in vehicles designed to operate using gasoline.

When blending methanol in gasoline several points must be considered:

i) Fuel octane rating is increased when blending methanol in gasoline.

ii) The existing gasoline supply and distribution infrastructure can be utilized with little or no modification.

iii) With correct choice of oxygenate level, blends can be utilized in existing gasoline vehicles without changes to fuel delivery components.

iv) Blends are susceptible to phase separation caused by water contamination. This problem is aggravated by cold temperatures. Cosolvents are used to reduce the potential for phase separation. Typical cosolvents include higher alcohols such as isobutanol, tertiary butanol and isopropanol.

v) Blends contain oxygen, hence they have the effect of leaning the fuel mixture, i.e. the amount of oxygen (air) required for combustion of the blend is reduced compared to gasoline.

vi) Methanol has approximately half the volumetric energy density of gasoline, therefore a slight loss in volumetric energy density is associated with blending.

vii) Blends are potentially corrosive to various vehicle materials such as terne plating (used in fuel tanks) and aluminum. Some elastomers may be effected by blends.

viii) Aldehyde emissions are associated with the combustion of alcohol containing fuels. Aldehyde emissions are currently unregulated by the federal government.

ix) Blending methanol and gasoline results in an increase in Reid Vapour Pressure. In order to avoid vehicle driveability difficulties the base gasoline requires tailoring to ensure that the resulting blend has an acceptable distillation curve.

1.2 Vehicle Driveability

A critical area of concern for vehicle operation is driver perception of driveability. When considering alternative fuels, public acceptance of the fuel will depend on the vehicle's driveability using the fuel in addition to the economics, convenience and safety associated with its use. Clearly, if a vehicle suffers from poor driveability, the new fuel will be less likely to be accepted.

Driveability is especially important for low level blends of methanol which will be used in existing unmodified gasoline vehicles and if marketed will be compared to regular gasolines.

1.2.1 Driveability Definition

Driveability may be considered as the manner in which a vehicle reacts to various throttle inputs, how easily the vehicle starts when cold and hot and the transient behaviour between cold and operating temperatures. Vehicle driveability is primarily influenced by engine operating characteristics which in turn are dependent upon the number and configuration of cylinders, fuel induction systems and by the fuel. Vehicle driveability can also be affected by transmission characteristics. It should be noted that driveability does not refer to vehicle handling determined by chassis design, suspension and tires. Typical indicators of poor driveability are vehicle hesitations, stumbles, backfiring, surging and stalling (see Glossary).

1.2.2 Factors Influencing Driveability

In addition to the powertrain configuration of a vehicle there are several factors influencing driveability, including ambient temperature, humidity, the state of vehicle "tune-up" and fuel characteristics (distillation curve, stoichiometric air/fuel ratio, energy content and composition).

The Coordinating Research Council (CRC) has conducted numerous driveability tests of alcohol blended fuels and distillation curve modified gasolines over various temperature ranges. Using a strictly defined test route and throttle maneuver, then assigning demerits todriveability faults,they have found that temperature and fuel characteristics do have effects on driveability.

The state of vehicle "tune-up" has a significant effect on driveability. A vehicle having incorrect spark advance, air/fuel ratio calibration or worn spark plugs will exhibit poor driveability characteristics. In fact, a deterioration in vehicle driveability is a sign to many vehicle owners that a tune-up is required.

A difference in driveability might be expected with the methanol blends because of the slightly lower energy density and the leaning effect associated with blending (points v and vi in section 1.1).

2. THE COLD START DRIVEABILITY TEST PROCEDURE

The ITC driveability test route is based upon similar test routes designed and used by CRC. A wide range of throttle maneuvers are performed at specified points along the test route. An intake manifold vacuum gauge is used to ensure that all maneuvers are conducted at predetermined throttle openings. Test runs are conducted by trained ITC personnel, who follow the test route using the designated throttle maneuvers and complete a driveability test report (Figure 1) as the test is performed. Once test runs are completed a demerit system is used to evaluate vehicle driveability. The demerit system assigns points to the various types of driveability faults and will allow a statistical comparison of driveability using the M4.75 and gasoline fuel.

The following sections (2.1 to 3.1.1) will describe the above mentioned aspects of the ITC driveability in detail.

Figure 1

INDUSTRIAL TECHNOLOGY CENTRE

Cold Start Driveability Test Report

Vehicle: _____

Date: _____

Time: Start _____

Finish _____

Driver: _____

Ambient Temp: _____

Rel. Humidity: _____

Road Conditions: _____

_____

Cold Soak: _____

Odometer:

Start: _____ km

Finish: _____ km

Starting:	Cold	Warm
Number of Attempts		
Total Cranking Time (sec.)		
Idle Stalls		
In Gear Stalls		

Maneuver:

No.	Description	Sm	Rgh	Hes	Stm	Srg	BF	Stall Ac	Stall Dc
1	Idle Qlty								
2	WOT								
3	MT								
4	LT								
5	MT								
6	Crowd								
7	WOT								
8	Crowd								
9	WOT								
10	MT								

Figure 1 cont'd

INDUSTRIAL TECHNOLOGY CENTRE
Cold Start Driveability Test Report - continued

Maneuver No.	Description	Hes	Stm	Srg	BF	Stall Ac	Stall Dc
11	WOT						
12	LT						
13	Crowd						
14	LT						
15	MT						
16	Crowd						
17	MT						
18	LT						
19	LT						
20	WOT						
21	MT						
22	Crowd						
23	LT						
24	MT						

		Sm	Rgh
25	Idle Qlty		

		Hes	Stm	Srg	BF	Stall Ac	Stall Dc
26	Crowd						
	HIGHWAY						
27	WOT						
28	WOT						
29	Crowd						
30	MT						
31	LT						
32	WOT (Ramp)						
33	MT						
34	LT						
35	Crowd						
36	WOT						

		Sm	Rgh
37	Idle Qlty		

Run-On Time: _____ Sec

Overall Rating: Good____ Acceptable____ Poor____

Please comment and note any unusual conditions or events:

_____

_____

_____

2.1 The Test Route

The driveability test route has a total length of 27.5 km with 10.8 km suburban driving and 16.7 km highway driving. The test route uses public roads adjacent to the ITC office building. Each test run requires approximately 43 minutes to complete. The test route is strictly defined, reducing the number of uncontrolled variables. The only factors which may affect running the test route as planned would be the presence of road construction or abnormal traffic conditions (caused by traffic accidents or weather conditions).

The route uses a total of 37 throttle maneuvers. The breakdown of throttle maneuvers is given in Table I.

Table I: Breakdown of Throttle Maneuvers Used for the ITC Driveability Test Route

Maneuver	Suburban	Highway	Total
Wide Open Throttle	5	4	9
Medium Throttle	7	2	9
Light Throttle	6	2	8
Crowd	6	2	8
Idle Quality			3
			37

Although the majority of CRC tests utilize private test tracks, this was deemed unnecessary for the ITC driveability test route for several reasons:

a) The closest available track is located 120 km North of Winnipeg in Gimli.

b) There is no readily available snow and ice removal equipment.

c) There are no fuel storage or garage facilities at Gimli.

d) Overnight security would present a difficulty.

e) The use of the Gimli track would significantly increase the expense and manpower requirements of driveability testing.

The cold start driveability test procedure, route description and map is given in Appendix A.

2.2 Test Drivers

In order to minimize the effects of driver to driver differences in testing technique and driveability fault evaluation, the number of test drivers must be kept to a minimum. At any given time there should not be more than two active test drivers. Additionally a test series on a vehicle must be performed by the same test driver.

Several CRC driveability tests have assigned driver rating correction factors, however by assigning one driver to each vehicle such a correction factor is not required for the ITC test route.

Prior to conducting a test series the test drivers should perform a practice run together so that driving style and rating technique may be compared and discussed.

Although not necessary, two testers may conduct a test run or test series together with one tester performing all the driving and driveability fault evaluation and the other recording the results on the Cold Start Driveability Test Report sheet (CSDTR).

2.3 Vehicle Scheduling

The prime area of interest of the driveability testing is on cold weather starting and driveability. Accordingly driveability testing will be emphasized in the winter and fall/spring months.

Based upon normal Winnipeg temperatures (Appendix B) cold weather testing will take place during the months of December, January and February when the temperatures are generally below -5°C. Intermediate temperature testing, 5°C to 15°C, should take place during September, October, April and May. To reduce the temperature window of the test series, each vehicle will be tested over 6 to 10 consecutive working days with the test series being divided between test runs using M4.75 and control gasoline. This will also ensure that the test series is conducted with the vehicle at the same state of tune-up and wear (tires, engine and transmission) reducing another area of variability.

The M4.75 project proposal calls for 10 vehicles to be driveability tested. The 10 vehicles chosen should be tested at intermediate temperatures, allowing a comparison of fuel and temperature effects on vehicle driveability.

2.3.1 Vehicle Selection

Vehicles used for driveability testing will be chosen from the M4.75 fleet vehicles supplied by the MVMA.

The MVMA has expressed a desire to examine late model vehicles to determine if the new M4.75 fuel will be compatible with the newer fuel handling systems.

Vehicles must be chosen according to availability with respect to the scheduling requirements (6 to 10 working days). Actual vehicle used will be determined by discussions with MTS (who will operate the AMC, Chrysler and GM test vehicles) and the regional Ford Administrator (who will operate the Ford test vehicles).

2.4 Vehicle Preparation

Test vehicles must have accumulated a minimum of 1000 km prior to testing to ensure that the vehicle has been "broken in".

The vehicles must also be prepared for the test series by determining intake manifold vacuum levels for the various throttle maneuvers, fuelling the vehicle with either M4.75 or control gasoline, driving the vehicle after refuelling and cold soaking the vehicle before the road test starts.

2.4.1 Vehicle Fuelling

Prior to the test series the test vehicles fuel tank must be drained and then refuelled with one of the two test fuels, either M4.75 or gasoline. This will be required since all M4.75 test vehicles will not use the M4.75 fuel exclusively. Refilling the tank before testing will eliminate potential effects caused by cross-fuelling.

The vehicle should be arbitrarily refuelled with either M4.75 or gasoline without informing the test driver. This will ensure that a blind test is conducted, eliminating any test biases caused by the Hawthorne Effect*.

After the desired number of test runs on the one fuel have been conducted (approximately 3 to 5 test runs) the tank must be drained again and refuelled with the other fuel.

2.4.1.1 Vehicle Preparation After Refuelling: Many late model vehicles employ electronic controls which adjust engine operation according to the fuel being used. These systems require some time to adjust to different fuels† and as such vehicles should be operated for a minimum of 50 km (more if possible) after refuelling to allow the vehicle to adjust to the new fuel.

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* The Hawthorne Effect is the observed phenomonen that test drivers or test subjects can conscientiously alter test results if they are aware of what is being tested and perceive that the test desires or expects results, be the positive or negative[2] (Ref. 2).

† The actual time required for this adjustment to occur is unknown with estimates ranging from as little as 20 minutes to as much as several hundered kilometers (Minutes of the April 4/84 CREADA Meeting at ITC Winnipeg).

2.4.2 Determinat on of Intake Manifold Vacuum Setting

After the test vehicle has been refuelled, but before the commencement of the test series the test driver(s) must determine the intake manifold vacuum settings for the test throttle maneuvers. Once determined, the settings must be used for all test runs for that vehicle (regardless of fuel being tested).

All vacuum settings should be determined with the vehicle at normal operating temperature. Once the vacuum settings have been determined they should be recorded on the Cold Start Driveability Test Summary sheet (Figure 2) and marked on the vacuum gauge (using tape). Sections 2.4.2.1 to 2.4.2.4 outlines the methods of determining intake manifold vacuum settings for the various accelerations.

2.4.2.1 Determination of Light Throttle (LT) Acceleration: With the test vehicle at a stand still, depress the throttle no more than 1/3 of wide open throttle (WOT) so that the vehicle accelerates at a slow to moderate rate. Record the initial vacuum reading and maintain constant throttle position for the duration of the acceleration. This initial vacuum setting will be used for all LT accelerations for the chosen test vehicle.

Figure 2

INDUSTRIAL TECHNOLOGY CENTRE

Cold Start Driveability Test Summary

Vehicle: _____

Test Driver: _____

Vehicle Description:

Cylinders/Configuration: _____

Displacement: _____ cc

Fuel Induction: _____

Transmission: _____

Manifold Vacuum Reading

To be determined prior to test series.

Acceleration Mode	Vacuum Reading	
Light Throttle	_____	in.Hg (initial setting)
Medium Throttle	_____	in.Hg (initial setting)
Crowd	_____	in.Hg (constant)

Test Summaries

Test No.	Fuel Used	Weather Conditions Temp. (°C)	Weather Conditions Rel. Hum (%)	TWD
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

2.4.2.2 Determination of Medium Throttle (MT) Acceleration: With the vehicle at a standstill, depress the throttle between 1/2 and 1/3 of WOT so that the vehicle accelerates at a moderate to brisk rate. As with the light throttle acceleration record the initial manifold vacuum reading and maintain constant throttle position for the duration of the acceleration. This initial vacuum setting will be used for all MT accelerations for the chosen test vehicle.

2.4.2.3 Determination of Crowd Acceleration: With the vehicle at a standstill, a vacuum setting must be chosen and maintained throughout the acceleration. This is done by gradually opening the throttle as the vehicle accelerates.

The vacuum setting chosen should lie between those determined for the LT and MT accelerations. Once determined, this vacuum setting will be used for all test crowds for the chosen test vehicle.

2.4.2.4 Wide Open Throttle Accelerations: All WOT accelerations are performed by fully depressing the throttle as quickly as possible without causing tire squeal or wheel spin, hence a predetermined vacuum setting is not required.

2.4.3 Cold Soak

Cold soak refers to the length of time a vehicle has not been operated. Test runs must be performed after an overnight cold soak of at least 10 hours, to ensure that the vehicle has reached ambient temperature. This will make certain that each test run examines cold starting and driveability as well as the transient behaviour between cold and operating temperatures.

2.5 Evaluation of Driveability Faults Using the Cold Start Driveability Test Report Sheet

The ITC driveability test route and procedure is described in detail in Appendix A and must be adhered to for all driveability test runs. Whenever a driveability fault occurs along the test route, it must be recorded at the appropriate section on the "Cold Start Driveability Test Report" sheet (CSDTR) (Figure 1), or if a driveability fault occurs during an unscheduled maneuver it should be reported under the comments and remarks portion of the CSDTR. The following four sections (2.5.1 to 2.5.5) describe the method of evaluating the severity of the various driveability faults.

2.5.1 Hesitations, Stumbles, Surges and Backfiring

When a hesitation, stumble, surge or backfire (see section 8), occurs, the test driver rates the severity of the fault as either noticeable (N) or troublesome (T). The appropriate box on the CSDTR is marked with an "N" and "T" depending upon the test drivers evaluation of the fault severity.

A noticeable fault is one which is apparent to the driver but does not greatly affect smooth and safe operation of the vehicle.

A troublesome fault is one which would be obvious to a passenger in the vehicle and would be annoying, potentially affecting the safe operation of the vehicle.

The severity of a hesitation or stumble can be based upon the time duration of the fault as well as the degree to which the power of the vehicle is reduced.

Surging severity can be based upon duration and the degree (i.e. amplitude) of the power fluctation.

Backfires severity is based upon the size of the explosion and/or the number of occurences during the throttle maneuver.

2.5.2 Stalls

Stalls are evaluated for each occurence. Driving stalls are classified according to type, either accelerating (AC) or decelerating (DC) by checking the appropriate box on the CSDTR.

Idle stalls occuring after start up are recorded by marking the stall boxes with "ID"

2.5.3 Cranking Time and Run-On Time

Both cold and warm cranking time and run-on time are recorded in seconds in the appropriate spaces on the CSDTR.

2.5.4 Idle Quality and Idle Stalls After Starting

Idle quality is rated as being smooth (Sm) or rough (Rg) by checking the appropriate space for maneuvers 1, 24 and 37 on the CSDTR. The number of idle stalls and in-gear stalls occuring after the cold and warm starts are recorded in the starting section on page 1 of the CSTDR.

2.5.5 Overall Rating

The overall rating section of the CSDTR on page 2, allows the test driver to subjectively evaluate the vehicles overall performance by checking either "good", "acceptable" or "poor". Table II gives a guideline for evaluating overall vehicle performance.

Table II: Guideline for Evaluating Overall Vehicle Performance

Rating	Vehicle Performance
Good	Vehicle exhibits good cold and warm driveability with few or no faults occuring during the test. Perhaps, slight hesitation, stumble or backfiring when cold but problems clear up quickly.
Acceptable	Vehicle exhibits good warm driveability but may suffer from severe cold hesitations, stumbles or backfires. Several attempts to start cold engine may be required.
Poor	Vehicle suffers from poor starting and other driveability faults when both cold and warm. Vehicles which suffer from a driving stall at any time during the test would immediately obtain a poor rating since this fault is potentially dangerous.

3. DRIVEABILITY TEST ROUTE DEMERIT SYSTEM

To allow comparison of test runs and to obtain an indication of vehicle driveability, a demerit system using weighting factors is applied to the different driveability faults as reported on the CSDTR.

The demerit system is based upon that used by the CRC. All driveability faults have a demerit point value assigned to them. The faults which are given a severity rating on the CSDTR (hesitation, stumbles, surges and backfires) are given an additional weighting factor which accounts for the difference in "unacceptability" of the fault.

The entire test run is given a Total Weighted Demerit (TWD) number which is the sum of all the individually occurring fault demerits.

Table III lists the demerit schedule assigned to the various driveability areas found on the CSDTR.

After a test series has been completed, the TWD and weather information for each test run should be entered on the "Cold Start Driveability Test Summary" report (Figure 2).

Table III: Demerit Calculation

1. Starting Demerits = Cold cranking time + warm cranking time - 2 sec.
   (minimum demerit = 0)

2.* Driveability Faults rated according to severity are calculated by multiplying the severity demerit value by the fault weighting factor (applicable to maneuvers 2 to 24, 26 to 36).

Severity Rating	Demerits
Clear	0
Noticable	2
Troublesome	4

Driveability Fault	Weighting Factor
Hesitation	6x
Stumble	6x
Surge	4x
Backfire	4x

Weighted Demerits = [driveability fault weighting factor x severity rating demerits]

3. Idle Demerits [Applicable to maneuvers 1, 25 and 37]

Rating	Demerits
Smooth	0
Rough	2

4.* Stall Demerits [Assigned per occurence, maneuvers 2 to 24, 26 to 36]

Type of Stall	Demerits
In gear idle	8
in gear driving	32

NOTE: Stalls occuring while attempting to start an engine are not included in this schedule.

5. Run-On Demerits = Total run-on time (seconds) x 2.

6. Total Weighted Demerits = (obtained by summing 1 to 5)

TWD = Starting demerits + weighted demerits + idle demerits + stall demerits + run-on demerits.

* When a throttle maneuver results in two or more driveability faults, all faults must be recorded but the maximum allowable demerits for any one maneuver is 32.

4. STATISTICAL ANALYSIS OF RESULTS

Statistical analysis of results will be directed largely by the temperature range occurring over the test series since temperature and weather are the only uncontrollable test factors affecting the test series.

The total weighted demerits will be used as the comparison statistic for evaluating driveability differences between test runs using M4.75 fuel and gasoline. The following section provides a guideline for using statistical analysis to determine if driveability is worse using M4.75 fuel than gasoline.

4.1 Steps for Comparing Driveability Using Total Weighted Demerits

If a test series occurs over a small temperature range (less than 8°C) all test run data can be used. If the range of temperatures is large, the test runs occurring outside of the most prominent range should not be used for the statistical analysis. To compare driveability using M4.75 and gasoline the mean of test run TWD using M4.75 will be compared to the mean of test run TWD using gasoline. The difference between the means will be tested using a one tailed student t-test statistic.

The following steps outline the statistical method, explanation for each step are bracketed.

i) The Null Hypothesis; H_0: $\mu_{4.75} - \mu_{gas} = 0$

[The difference between the means of TWD for M4.75 test runs and control gasoline test runs is equal to zero i.e there is no differences in driveability using the two fuels]

ii) The Alternate Hypothesis; H_1: $\mu_{4.75} - \mu_{gas} > 0$

[The difference between the means of TWD for M4.75 test runs and control gasoline runs is greater than zero i.e. driveability using M4.75 is poorer than driveability using gasoline as indicated by TWD]

iii) Choose the Level of Significance; $\alpha = 0.05$

[Previous ITC tests have used a level of significance (α) equal to 10 (90% confidence interval), it is suggested that $\alpha = 0.05$ (95% confidence level be used since results reported at this level can be reported as being statistically significant]

iv) Test Statistic

The population of test runs using M4.75 and gasoline are assumed to be equal but are unknown, hence the appropriate test statistic is:

$$t = \frac{(\bar{x}_{4.75} - \bar{x}_{gas})}{S_p \sqrt{\frac{1}{n_{4.75}} + \frac{1}{n_{gas}}}}$$

Where:

$\bar{x}$ = sample mean of test runs TWD

n = sample size

S_p = pooled sample standard deviation

$$S_p^2 = \frac{(n_{4.75} - 1) S^2_{4.75} + (n_{gas} - 1) S^2_{gas}}{n_{4.75} + n_{gas} - 2}$$

Where:

S^2 = sample variance

Sp^2 = pooled sample variance

NOTE: $s_p = \sqrt{s_p^2}$

$$* = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$S = \frac{n \sum_{i=1}^{n} x^2_i - \left(\sum_{i=1}^{n}\right)^2}{n(n-1)}$$

v) Critical Region

The critical region resulting from the chosen alternative hypothesis is:

$t > t_{0.05}$ with degree of Freedom (γ)

$$\gamma = n_{4.75} + n_{gas} - 2$$

$t_{0.05}$ is determined by using a t distribution table (from most statistical texts such as Ref. 3 and Ref. 4)

vi) Decision

A decision can be reached once the test statistic has been calculated from the test series data

If: a) Test statistic, t, lies in the critical region.
Decision: Reject the Null Hypothesis

[i.e. driveability using M4.75 is significantly poorer than driveability using gasoline as indicated by TWD]

b) Test statistic, t, lies outside the critical region.
Decision: Fail to reject the Null Hypothesis

[i.e. there is no significant difference between vehicle driveability using the two different fuels based on test results using TWD as an indicator of driveability]

5. TENTATIVE DRIVEABILITY SURVEY DEMERIT SYSTEM

The proposed demerit system is based loosely on the system used by the Coordinating Research Council (CRC) in the "1973 Driveability Instrumentation Tests", CRC-489. The demerit system is designed to allow comparison of M5 and M90 fueled vehicles with the control vehicles by assigning demerit points to vehicle operator responses on the "Fleet Testing Survey - Weekly Log Sheet" (Fig. 3).

5.1 Demerit Points Scheme and Weighting Factors

The rating columns on the survey sheet are given the following demerit values:

Good, never = 0

Acceptable, occasionally = 2

Poor, often = 4

The higher demerit points will indicate vehicles with poor driver perceived driveability.

For assessing relative vehicles ratings each of the 10 engine related questions are assigned a weighting factor. The weighting factors reflect the relative severity or unacceptability of the engine faults in question. The more undesireable faults (with respect to vehicle driveability and safety) are represented by higher weighting factors. Where similar survey faults existed between the ITC survey and CRC survey, the CRC weighting factors were used (with the exception of backfiring, which will be discussed later). The faults which coincide between the two surveys are: idle quality, hesitations and stumbles, backfiring and driving and idling stalls.

The final demerit rating for each vehicle is determined by multiplying the checked rating factor with the appropriate weighting factor, then summing the total of the 10 questions. This final number is referred to as the Total Weighted Demerits (TWD).

5.2 Description of Survey Engine Characteristics

5.2.1 Stalling in Traffic - Weighting Factor (WF) = 16x

Of the faults surveyed, stalls in traffic receives the highest WF because this type of fault is not only very annoying but can also be very dangerous in traffic. Undoubtedly most vehicle operators would find a vehicle which stalled in traffic totally unacceptable.

5.2.2 Hesitation, Stumbles and Bucking - WF = 6x

This type of driveability fault can be described as temporary lack of engine response or power during acceleration. A hesitation occurs when the lack of response precedes the vehicle acceleration. A stumble occurs when the lack of response takes place during the acceleration, i.e. after the vehicle has started accelerating but before a constant vehicle speed is reached.

This type of fault is given a high WF because they are quite annoying, easily recognizable and depending on the severity (or duration) can be dangerous in traffic.

5.2.3 Stalling after starting - WF = 4x

Engine stalls after starting is recognizable to all drivers and as such would influence the overall driveability assessment of the vehicle. Since it does not affect the safe operation of the vehicle, it does not received a WF as high as that for hesitations or traffic stalls.

5.2.4 Backfiring - WF = 4x

An explosion in the induction or exhaust system is easily noticed by the driver and depending on the severity can be very annoying, thus affecting the vehicles driveability rating. CRC gives backfire a 6x WF, however, the proposed ITC demerit system gives it a WF of 4x because it is deemed less offensive than a hesitation (which is given a 6x WF).

5.2.5 Engine run-on or dieseling - WF = 2x

5.2.6 Overall performance - WF = 2x

This question allows the driver to give some objective input into the survey.

5.2.7 Cranking Time to Start Engine; Engine Idling; Power and Engine Knock - WF's = 1x

These engine characteristics are dependent upon the drivers sensitivity and expectations of vehicle performance. Some drivers may accept some engine knock and low power while others may not. Due to the wide spectrum of driver attitudes to these engine characteristics and their negligible affect on vehicle safety, these faults receive a low weighting factor.

5.2.8 Surge - not included

Surging, defined as a cyclic power fluctuation, was not included in the ITC driveability survey. It is felt that most drivers would be unfamiliar with this type of fault and might confuse the term with other engine phenomenon, particularily with stumbles and hesitations. Additionally this type of fault is very uncommon and is usually only noticeable to trained drivers who are testing for driveability faults.

5.3 The CRC Driveability Test Procedure

The CRC driveability test procedure uses a few, carefully selected, trained test drivers to perform vehicle driveability test runs. A test route and procedure (which specifies when and what type of throttle maneuver are performed) is developed and adhered to by the drivers. In an effort to reduce the number of uncontrolled variables, the number of test drivers is kept to a minimum, and only those tests performed within a certain temperature interval are compared. A typical temperature window is 10°F, i.e. 32 - 42°F. Vehicles are usually soaked, (i.e. not driven) for 6 to 8 hours before tests so that cold starting and driveability can be examined. Each driver is given an additional weighting factor which accounts for the individual differences in the subjective ratings of the vehicles. The weighting factor is obtained by measuring driver rating against engine recordings of RPM, manifold vacuum, car speed and throttle position and then using this information to correct for differences in the drivers rating severity.

The monitored driveability faults and their CRC weighting factors are:

		WF	
1)	Idle roughness	1x	
2)	Hesitations	6x	
3)	Stumbles	6x	
4)	Surges	4x	
5)	Backfire	6x	
6)	Stalls - driving	32	Demerit points per occurence
	idle	6	

All driveability faults are independently recorded as they occur for each test run. Items 1 through 5 are further assigned a severity rating of:

Trace	= 1 demerit
Moderate	= 2 demerits
Heavy	= 4 demerits

which is multiplied by the weighting factors.

A possible example of a CRC evaluation sheet, although no actual sheet was found, might be:

Test Maneuver #	Driveability Fault Type	Severity	Weighted Demerits (TWD)
1	Hesitation	Moderate	6 x 2 = 12
2	---	---	0
3	Idle roughness	Trace	1 x 1 = 1
4	Backfire	Heavy	6 x 4 = 24
5	---	---	0
.			
.			
.			
XX	Stumble	Trace	6 x 1 = 6
			TWD = XXX

The test maneuver numbers would refer to specific driving maneuvers, e.g. light, medium or wide open throttles, crowds (smooth and constant opening of throttle), idling, etc. and their location along the test route.

The TWD is obtained by summing the individual weighted demerits.

5.4 Differences Between the Proposed ITC and CRC Surveys

Although the CRC Demerit Point System was used as a guideline for the ITC Demerit System, it should be noted that the two methods of evaluating vehicle driveability are unrelated.

The goal of the ITC survey is to obtain an objective driveability comparison of vehicles using M5, M90 and a control gasoline, and to expose any major differences between vehicle driveability using the three different fuels. The CRC test method is designed to subjectively evaluate vehicle driveability in a way to minimize the number of uncontrolled variables.

The following table compares various aspects of the ITC and CRC driveability assessment procedures.

ITC	CRC
Fleet vehicle operators using the vehicles as a part of normal business duties.	Selected, trained test drivers whose testing and evaluating techniques are weighted amongst each other.
Evaluation sheets completed at the end of each week.	Evaluation sheet completed for each test run.
Unspecified combination and duration of city and rural driving. Ambient weather conditions are not monitored.	Specified test route with the number and type of throttle maneuvers strictly adhered to. Ambient weather conditions monitored at the time of each test.
Type and relative frequency of driveability faults monitored.	Type, relative severity and maneuver causing each driveability fault monitored.

Weighting Factor Comparison

Engine Characteristic	ITC	CRC
Hesitation, stumble	6X	6X
Idle roughness	1X	1X
Backfire	4X	6X
Cranking time to start engine	1X	-
Surge	-	4X
Stalls - driving	16X	32 demerits per occurrence
- idle	4X	6 demerits per occurrence
Overall performance	2X	-
Power	1X	-
Engine knock	1X	-
Engine run-on	2X	-

Figure 3

INDUSTRIAL TECHNOLOGY CENTRE/MANITOBA RESEARCH COUNCIL

Fleet Testing Survey - Weekly Log Sheet

Vehicle No.: _____ Type: _____

Date: _____ Driver Name: _____

Odometer Reading: _____ Fuel Used: _____

Servicing: Litres of Oil Added: _____

Maintenance Required: Yes____ No____

If yes, please describe: _____

_____

_____

Please rate the following engine related characteristics (mark appropriate column with a check)

	Weighting Factor	Rating Factor		
		Good 0	Acceptable 2	Poor 4
1) Cranking time to start engine	1x	___	___	___
2) Engine idling	1x	___	___	___
3) Overall performance	2x	___	___	___
4) Power	1x	___	___	___
		0 Never	2 Occasionally	4 Often
5) Stalling after starting	4x	___	___	___
6) Stalling in traffic	16x	___	___	___
7) Engine knock or pinging	1x	___	___	___
8) Engine run-on or dieseling	2x	___	___	___
9) Hesitating, stumbling or bucking	6x	___	___	___
10) Backfiring	4x	___	___	___

If any problems occur, please describe the type of driving and the approximate temperature for each problem:

_____

Minimum Rating - 0 Demerits (TWD)

Maximum Rating - 152 Demerits (TWD)

_____

6. CONCLUSIONS AND RECOMMENDATIONS

The ITC driveability test route will effectively compare vehicle driveability using the M4.75 test fuel and gasoline.

The manpower and time requirements of the ITC driveability test as described, are much lower than would have been needed had a private test track been used.

Reliable test run results will be obtained since each test vehicle will be assigned to only one driver. Test biasing due to the Hawthorne effect will be reduced by conducting blind tests, i.e. the test drivers will not be aware of the fuel being tested.

The demerit system used by the ITC driveability test route has been adapted from Coordinating Research Council demerit systems, hence it will accurately reflect vehicle drivability.

The revised fleet survey questionnaire will yield a greater quantity and quality of information than the previously used survey sheet. The questions are less ambiguous and the questionnaire is easier for the regular vehicle operators to complete.

In order to evaluate cold starting and cold driveability peformance of the M4.75 fuel, testing should be conducted during the winter months (December to February). Additionally, several vehicles should be tested at intermediate temperatures during the fall/spring months (September, October, April and May) to evaluate the temperature effects on driveability.

The level of significance chosen for statistical analysis should be α = 0.05 (95% confidence level) so that results may be reported as being statistically "significant".

7. REFERENCES

1. Coordinating Research Council, Inc. 1982. "Effects of Fuel Volatility on Driveability of 1980 Model Cars at Low and Intermediate Ambient Temperature". Coordinating Research Council Inc., Atlanta.

2. Meuller Associates, Inc. 1982. "A Comparative Assessment of Current Gasohol Fuel Economy Data: A 1982 Update". American Petroleum Institute Alcohol Fuels Task Force, Washington, D.C.

3. Ontario Ministry of Transportation and Communications, 1983. "Federal/Provincial Methanol Vehicle Test Program". Road and Motor Vehicle Traffic Safety Directorate, Transport Canada, Ontario Ministry of Transportation and Communications, Downsview.

4. Walpole, R. E., 1982. "Introduction to Statistics" 3rd Edition. MacMillan Publishing Co. Inc. New York.

8. GLOSSARY

Backfire - An explosion in the induction or exhaust system caused by combustion of fuel outside of the combustion chamber.

Cold Soak - The length of time that a vehicle has not been operated.

Crowd - An acceleration made at a constant intake manifodl vacuum. The throttle must be continuously opened with increasing engine speed.

Cruise - A predetermined constant driving speed on level road. Unless otherwise stated, it is the posted speed limit.

Driveability - The overall behaviour of a vehicle and the way in which it is perceived by the driver. Factors influencing drivability evaluation include vehicle response to various throttle maneuvers, power and acceleration, idle quality, cold starting and performance.

Hesitation - A temporary lack of vehicle (engine) response to a throttle maneuver. The vehicle may creep ahead or accelerate slower than expected. Depending upon the severity of the hesitation, the duration may be short (less than 1/2 sec) or long (up to 5 seconds or more).

Idle Quality - evaluation of the degree of smoothness or roughness of engine idling. Idle quality may be evaluated with the automatic transmission in neutral, park or in gear.

Knock/Pinging - combustion of fuel in the combustion chamber which is not initiated by a spark (in a spark ignition engine). This type of fault usually occurs at high load/low rpm conditions, the resulting sound can be compared to "shaking marbles in a tin can".

Maneuver - A predetermined vehicle operation which specifies a change in vehicle operating condition or any other event which must be observed by the test driver during a test run. Maneuvers include accelerations, engine start up or shut down, idling and cruising.

Medium Throttle Acceleration (MT) - A moderate acceleration made at a constant throttle position (between 1/2 and 2/3 of wide open throttle position).

Run-On/Dieseling - A continuance of engine revolution after the ignition has been switched off.

Stall - Occurs when the engine stops operating with the ignition switched on. Stalls may occur while idling or when accelerating or decelerating.

Stumble - Similar to a hesitation but the lack of throttle response occurs after the acceleration has begun. The vehicle may lose speed, maintain speed or accelerate slower than expected.

Surge - A cyclic power fluctuation occurring during an acceleration or cruise. Severity is determined by duration and magnitude (amplitude) of the power fluctation.

Test Run - A single operation of a test vehicle over the ITC driveability test route, beginning with the first attempted start up and ending with the final engine shut down.

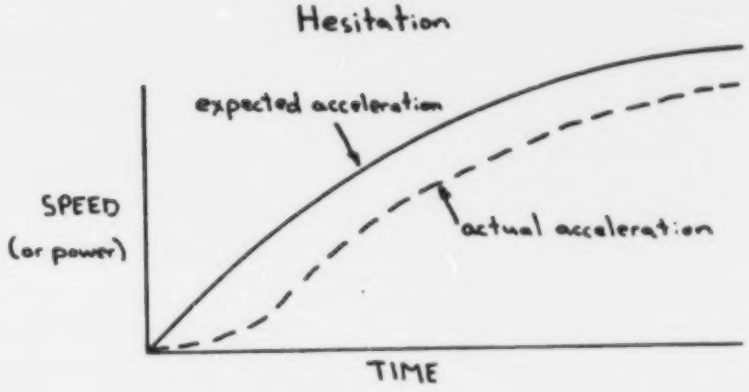
Test Series - The combination of consecutive test runs using one vehicle, one driver and a combination of test fuels.

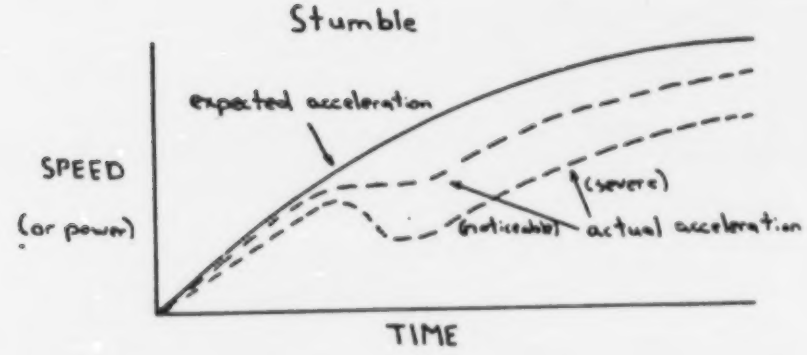
Throttle Taps - Several quick repeated throttle openings (in neutral or park) designed to disengage automatic chokes.

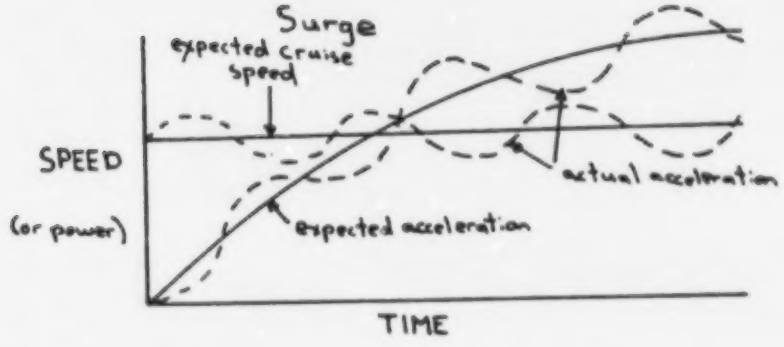
Wide Open Throttle Acceleration (WOT) - Complete opening of the throttle. The throttle being depressed as fast as possible without causing wheel spin or tires squealing.

Figure 4

GRAPHICAL REPRESENTATION OF HESITATIONS, STUMBLES AND SURGES







APPENDIX A

Test Run Route and Maneuvers

A.0 Test Run Route and Maneuvers

After the test vehicle has been cold soaked and prepared as described in sections 2.1 to 2.4.3, the test run can be performed by the assigned test driver.

A.1 Pre-Test Preparation

The test begins by recording all preliminary information on the CSDTR (Figure 1). This includes ambient temperature, humidity, a brief description of road conditions, starting time and odometer reading, vehicle tested, driver and date.

Ensure that the manifold vacuum gauge is properly connected and that the accleration vacuum settings are clearly labeled on the gauge.

A.2 Start-Up and Parking Lot Maneuvers

A.2.1 Start the engine according to the owners manual. If no instructions are given, the following schedule should be used:

Carbureted Vehicles: Fully depress and release the throttle twice and crank the engine with foot off the throttle.

Fuel Injected Vehicles: Slightly depress and hold the throttle while cranking the engine.

* Record cranking time to start in seconds.

A.2.2 If the engine fails to start after 6 to 8 seconds of cranking, stop for 10 seconds and repeat A 2.1.

* Record total cranking time and number of attempts needed to start engine.

If this method does not start engine, use any throttle manipulation deemed necessary to start the engine.

A.2.3 Allow the engine to idle for 45 seconds with the transmission in "park".

A.2.4 Shift transmission into gear with right foot on the brake.

* Record idle quality (maneuver #1).

Allow engine to idle for 5 seconds in gear.

* Record number of stalls (if any) and repeat steps A.2.1 to A.2.3 until a successful start is obtained.

A.2.5 Drive through the ITC parking lot towards Lagimodiere Blvd.

Carbureted Vehicles Only: Stop before turning right on Niakwa Road, place transmission in "park" and perform a series of throttle taps. Place transmission in gear and proceed to the stop sign.

A.2.6 Begin maneuvers as given insect. A.3. All accelerations are to be performed until the posted speed limit is reached and adhering to the indicated throttle position using the intake manifold vacuum gauge.

A.3 Suburban Section of Driveability Test Route Maneuvers

Maneuver Number	Direction	Street (Turning on to)	Maneuver	Km
1	Start	---	Idle Quality	0.00
2	R	Lagimodiere Blvd.	WOT (to 80 km/hour)	0.25
3	L	Betournay St.	MT	1.65
4	1st Stop Sign	---	LT_x	2.00
5	2nd Stop Sign	---	MT_x	2.25
6	L	Autumnwood Dr.	Crowd	2.70
7	1st Stop Sign	---	WOT	3.20
8	L	Crestwood Dr.	Crowd	3.60
9	1st Stop Sign	---	WOT	4.05
10	L	Westmount Dr.	MT	4.60
11	1st Stop Sign	---	WOT	4.80
12	L	Cottonwood Road	LT	5.20
13	R	Dussault Ave.	$Crowd_x$	5.30
14	L	Betournay St.	LT	5.80
15	1st Stop Sign	---	MT	6.05
16	R	Autumnwood Dr.	Crowd	6.50
17	R	DeBourmont Ave.	MT	6.85
18	L	Elizabeth Road	LT	7.30
19	L	Drake Blvd	LT_x	7.75
20	1st Stop Sign	---	WOT_x	8.25
21	L	Cottonwood Road	MT_{xx}	9.00
22	R	Autumnwood Dr.	$Crowd_{xx}$	9.30

A.3 Suburban Section of Driveability Test Route Maneuvers

Maneuver Number	Direction	Street (Turning on to)	Maneuver	Km
23	L	Crestwood Dr.	LT	9.75
24	1st Stop Sign	---	MT	10.20
25	2nd Stop Sign	---	Idle Quality	10.75
26	R	Westmount Dr.	Crowd	10.75
27	L	Fermor (TransCanada)	WOT (to 80 km/hour)	10.80

All accelerations are to 50 km/hour unless otherwise specified.

Abbreviations

R = right turn

L = left turn

X_{xx} S.S. = stop sign

WOT = Wide Open Throttle

MT = Medium Throttle

LT = Light Throttle

Crowd . = Crowd

X = Pedestrian Crosswalks

ON	AT	KM
Bertournay St.	Vincent Massey Blvd	2.10
Bertournay St.	Howden Road	2.40
Autumnwood Dr.	Canberra Road	3.30
Dussault Ave.	Bibeau Bay	5.55
Drake Blvd.	Argonne Bay	7.90
Drake Blvd.	Brentwood Bay	8.50
Cottonwood Road	Cherry Cres.	9.20 and 9.25
Cottonwood Road	Autumnwood Dr.	9.30

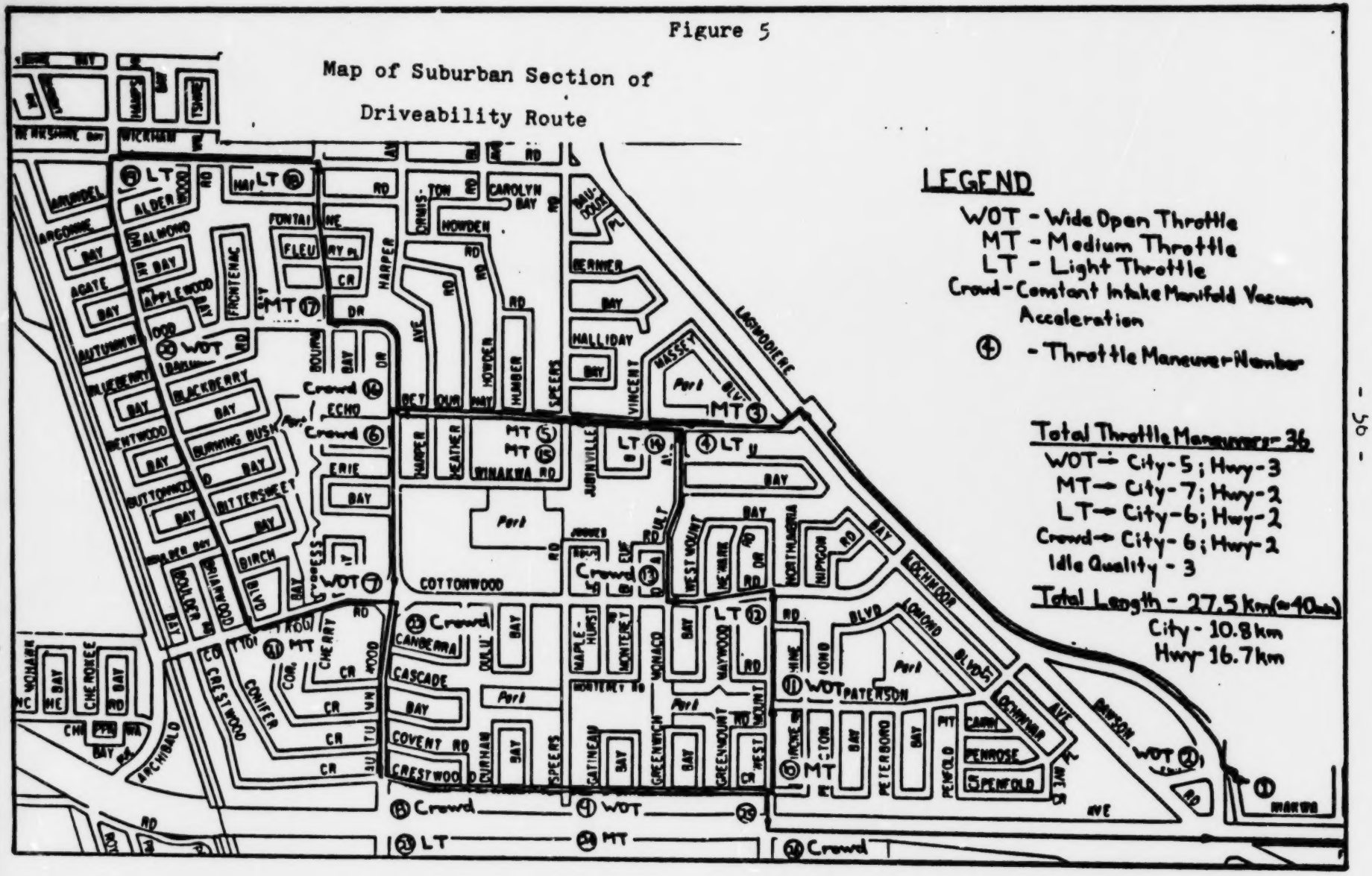
* **Caution:** Since public roads are utilized, all traffic regulations must be obeyed. Safe vehicle operation is a must at all times.

Throttle maneuvers 1 to 27 and 37 are shown on a map in Figure 5.

Figure 5

Map of Suburban Section of

Driveability Route



A.4 Highway Section of Driveability Test Route

A.4.1 Proceed through the lights at Lagimodiere at 70 km/hour. If there is a red light, do not record any driveability faults occurring on deceleration or acceleration. Any faults occurring at this time should be recorded under the "comments" section.

A.4.2 All highway accelerations should be performed from 70 km/hour to 90 km/hour. Between accelerations cruise at 80 km/hour.

A.4.3 Folow all the throttle maneuvers as listed in Figure 6.

Highway Section of Driveability Test Route Maneuvers

Maneuver Number	Marker	Maneuver	Km
28	90 km/hour speed limit sign	WOT	12.80
29	1st light pole after "no parking sign" (up overpass)	Crowd	13.60
30	"Symington Road" sign	MT	15.20
31	"Winnipeg By-Pass 2 Km" sign	LT	17.60
--	Follow "101 North Ramp" on the "Trans Canada West Ramp" (no lane change required)	--	19.00
32	With vehicle parallel to highway accelerate from 40 km/hr to 90 km/hr	WOT	20.00
33	"City Centre 14 km" sign	MT	21.00
34	"Hwy 1/135" sign	LT	22.40
35	Light pole with "TransCanada Highway" sign (up overpass)	Crowd	24.80
36	"Welcome to Winnipeg" sign	WOT	25.70

A.5 Completion of Test Run

A.5.1 After completion of the highway section of the test route continue to the ITC parking lot using the Lagimodiere entrance.

A.5.2 Stop the vehicle, idle in gear for 5 seconds.

* Record idle quality.

A.5.3 Place transmission in "park" and shut off the engine.

* Record run-on time in seconds.

A.5.4 Soak vehicle for five minutes. During this time complete the comments section, noting any unusual conditions or faults occurring at unscheduled maneuvers.

A.5.5 After five minutes, restart engine with foot off the accelerator.

* Record cranking time and number of attempts.

A.5.6 Shut off the engine.

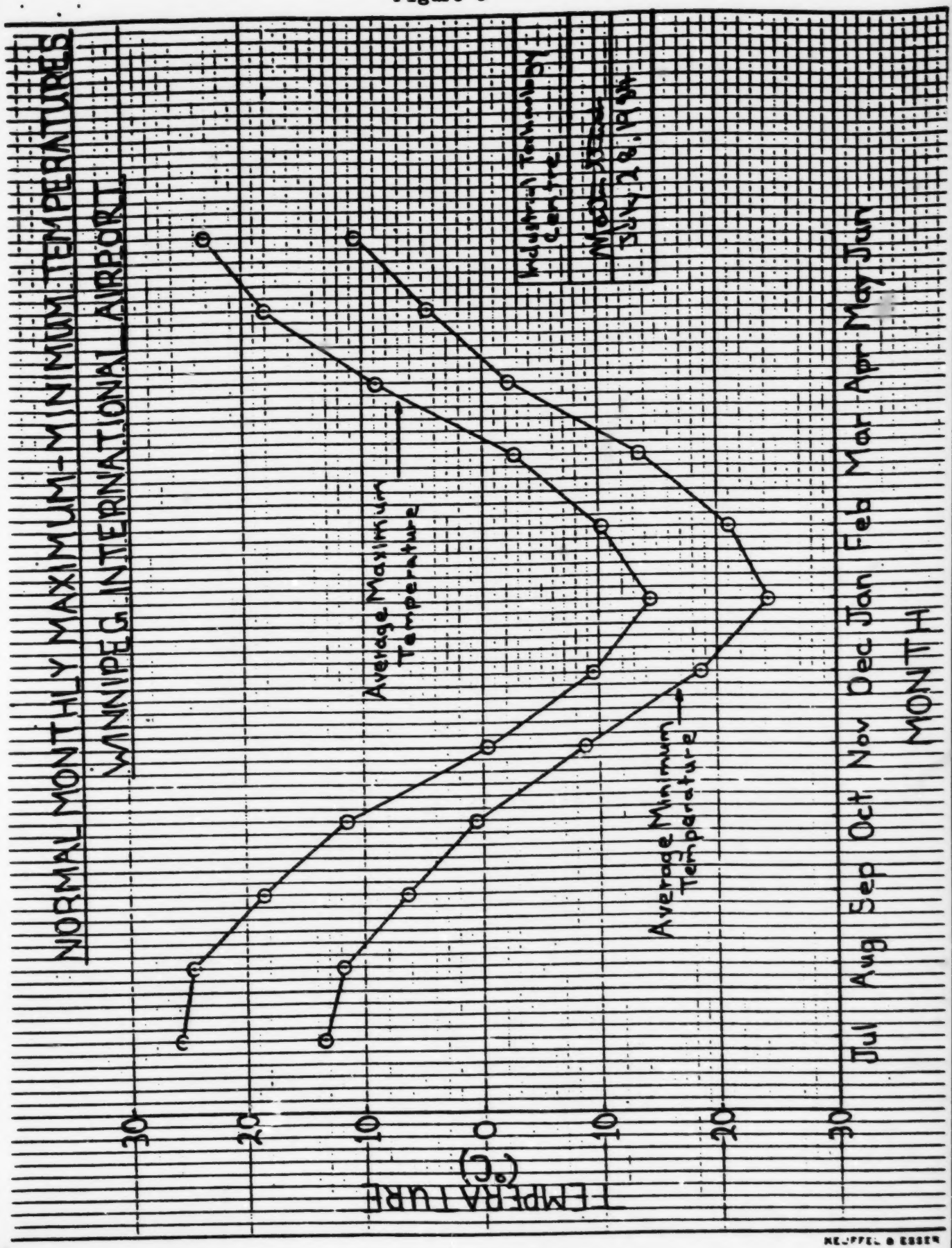
* Record run-on time (add to that obtained in section A.5.3.

A.5.7 Evaluate overall performance, ending time and odometer reading.

APPENDIX B

Normal Monthly Maximum - Minimum Temperature
Winnipeg International Airport

Figure 6


NORMAL MONTHLY MAXIMUM-MINIMUM TEMPERATURES
WINNIPEG INTERNATIONAL AIRPORT
Average Maximum Temperature
Average Minimum Temperature
TEMPERATURE (°C)
30
20
10
0
10
20
30
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun
MONTH

APPENDIX III

Statistical Analyses

Table AIII-1: Difference* in Specific Fuel and Energy Consumption Between RUG and M5 Fueled Vehicles on the Chassis Dynamometer at 48 km/h

		Degrees of Freedom	Specific Fuel Consumption (L/100 km)	Specific Energy Consumption (MJ/100 km)
1.6 L Engine Size B,B,B	$\bar{x}$	2	-0.270	-16.973
	S		0.191	25.063
	t(calculated)		-2.455	-1.173
	Significance Level		<90	<90
2.2 - 2.3 L Engine Size I,K,H	$\bar{x}$	2	0.160	-2.333
	S		2.114	61.635
	t(calculated)		0.131	-0.066
	Significance Level		<90	<90
3.7 - 3.8 L Engine Size T,R,T,T	$\bar{x}$	3	-0.718	-21.258
	S		0.439	20.898
	t(calculated)		-6.534	-2.034
	Significance Level		>99	<90
Overall 10 Test Vehicles	$\bar{x}$	9	-0.310	-9.360
	S		1.114	34.041
	t(calculated)		-0.880	-0.870
	Significance Level		<90	<90

* Difference was taken as RUG - Test Blend

Table AIII-2: Difference* in Specific Fuel and Energy Consumption Between RUG and M5 Fueled Vehicles on the Chassis Dynamometer at 88 km/h

		Degrees of Freedom	Specific Fuel Consumption (L/100 km)	Specific Energy Consumption (MJ/100 km)
1.6 L Engine Size B,B,B	$\bar{x}$ S t(calculated) Significance Level	2	0.310 0.499 1.075 <90	13.927 10.785 2.237 <90
2.2 - 2.3 L Engine Size I,K,H	$\bar{x}$ S t(calculated) Significance Level	2	0.316 0.330 1.662 <90	4.960 11.225 0.765 <90
3.7 - 3.8 L Engine Size T,R,T,T	$\bar{x}$ S t(calculated) Significance Level	3	-0.570 0.548 -2.081 <90	-18.975 24.766 -1.532 <90
Overall 10 Test Vehicles	$\bar{x}$ S t(calculated) Significance Level	9	-0.040 0.623 -0.203 <90	-1.924 22.069 -0.276 <90

* Difference was taken as RUG - Test Blend

Table AIII-3: Statistical Analysis of the ITC Cold STart Driveability Test Route Results

Test Number	Vehicle Type	Degrees of Freedom	Student's t (calculated)	Significance Level
1	O	4	0.058	<90
2	Q	5	0.495	<90
3	I	4	1.578	<90
4	A	4	2.973	>90
5	T	3	2.395	>90
6	D	5	7.783	>99
7	U	5	1.395	<90
8	E	2	1.388	<90
9	O	4	1.388	<90
10	T	6	2.371	>90
Overall first 9 tests		16	0.773	<90

Difference was taken as RUG - Test Blend